FISHERY RESEARCH

INTENSIVE EVALUATION AND MONITORING OF CHINOOK SALMON AND STEELHEAD PRODUCTION, CROOKED RIVER AND UPPER SALMON RIVER SITES

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Prepared by:

Russell B. Kiefer
Senior Fishery Research Biologist

and

Jerald N. Lockhart
Senior Fishery Technician

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Intensive Evaluation and Monitoring of Chinook Salmon and Steelhead Production Crooked River and Upper Salmon River Sites

Project Progress Report

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By

Russell B. Kiefer
Jerald N. Lockhart

Idaho Department of Fish and Game
600 South Walnut Street
P.O. Box 25
Boise, ID 83707

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ABSTRACT

The purpose of this intensive monitoring project is to determine the number of returning chinook and steelhead adults necessary to achieve optimal smolt production and develop mitigation accounting based on increases in smolt production. Two locations in Idaho are being intensively studied to meet these objectives. Information from this research will be applied to parr monitoring streams statewide to develop escapement objectives and determine success of habitat enhancement projects.

Major findings of the project in 1993 were:

1. Our data indicates that at most the irrigation diversions in the Challis Valley may slightly impact the survival of the tail end (<25% of the run) of the chinook salmon smolt migration during low flow years, and have no significant affect in normal flow years. This suggests to us that the irrigation diversions on the Salmon River are not a significant cause for the decline of Salmon River chinook salmon.

2. The estimated abundance of both chinook salmon and steelhead trout parr in the upper Salmon River was the lowest since intensive data has been collected beginning in 1984. This indicates that current measures taken to recover Salmon River anadromous stocks have not been successful.

3. In 1993 we observed the highest PIT tag detection rate at the Snake and Columbia rivers' smolt collecting dams for chinook salmon and steelhead trout smolts tagged at our emigrant traps in spring 1993 at both study areas. We attribute this to the higher migration survival resulting from the more normal spring flows in the Snake River drainage.

4. PIT tag detection data from the Snake and Columbia rivers' smolt collecting dams from migratory years 1990-1993 indicate that after a chinook salmon or steelhead trout parr have been successfully tagged during August, there is no significant difference in survival to out-migrating smolts whether they were collected with a seine or a backpack electrofisher.

INTRODUCTION

Project 83-7 was established under the Northwest Power Planning Council's 1982 Fish and Wildlife Program, Measure 704(d)(1) to monitor natural production of anadromous fish, evaluate BPA habitat improvement projects, and develop a credit record for offsite mitigation projects in Idaho. Project 83-7 is divided into two subprojects: general and intensive monitoring. Results of the intensive monitoring subproject are reported here. Results from the general monitoring subproject will be reported in a separate document (Leitzinger and Petrosky 1993, in press). Fieldwork for the intensive monitoring subproject began in 1987 in the upper Salmon River and Crooked River (South Fork Clearwater River tributary) study areas.

The goals of the intensive monitoring subproject are to quantify escapement objectives for wild/natural anadromous stocks that optimize smolt production and provide mitigation accounting based on increases in smolt production. Our approach to determine escapement needs for wild/natural anadromous stocks is: (1) to estimate egg deposition using weir counts of returning adults, redd counts, and carcass surveys; (2) to use snorkel counts and stratified random sampling to estimate parr abundance and egg-to-parr survival; (3) to PIT tag representative groups of parr and use PIT tag detections at the lower Snake and Columbia rivers' smolt collecting dams to estimate parr-to-smolt survival; and (4) to use adult outplants into tributary streams to estimate egg-to-parr survival and carrying capacity. Our approach to mitigation accounting based on increases in smolt production is: (1) to estimate parr production attributable to habitat projects; (2) to quantify relationships between spawning escapement, parr production, and smolt production; and (3) to use smolt production as a basis for assessing habitat improvement benefits.

OBJECTIVES

The objectives of this project are to determine:

1. The mathematical relationship between spawning escapement, parr production, and smolt production;
2. Carrying capacity and optimal smolt production; and
3. Habitat factors relating to substrate, riparian, and channel quality that limit natural smolt production.

STUDY AREAS

Upper Salmon River

The Salmon River originates at elevations above 2,800 m in the Smoky Mountains in south central Idaho. The upper Salmon River (USR) study area is the entire Salmon River drainage upstream of the Sawtooth Hatchery weir at 1,980 m elevation (Figure 1). Tributary streams in the USR drain watersheds of the Sawtooth Range and Smoky Mountains on the west and the Boulder Mountains and White Cloud Peaks on the east. The Salmon River and tributaries upstream from and including Pole Creek are considered as headwaters upper Salmon River.

The river above Sawtooth Fish Hatchery is a major production area for spring chinook salmon *Oncorhynchus tshawytscha* and A-run summer steelhead trout *O. mykiss*. Other resident salmonids in the USR drainage are native rainbow trout *O. mykiss*, cutthroat trout *O. clarki*, bull trout *Salvelinus confluentus*, mountain whitefish *Prosopium williamsoni*, and nonnative brook trout *S. fontinalis* (Mallet 1974).

Historically, sockeye salmon *O. nerka* existed in all moraine lakes in the Stanley Basin (Everman 1895). An extremely depressed remnant run of sockeye salmon returns to Redfish Lake. The outlet of Redfish Lake enters the Salmon River approximately 2.7 km downstream from Sawtooth Hatchery. Occasionally, adult sockeye salmon have been seen in Alturas Lake Creek [K. Ball, Idaho Department of Fish and Game (IDFG), personal communication], but an irrigation diversion that completely dewatered the stream every summer made adult passage to the lake unlikely (Bowles and Cochnauer 1984). In 1992, most of the Alturas Lake Creek water rights were purchased, and the irrigation diversion was rebuilt with Bonneville Power Administration (BPA) mitigation funding. Adult sockeye salmon passage is now possible. No other sockeye salmon runs are known to exist in the Salmon River drainage.

Nearly pristine water quality and an abundance of high quality spawning gravel and rearing habitat is present throughout much of the upper basin. Water flows at the Sawtooth Hatchery range from lows of 1.73-3.46 m^3/s from July through April to highs of 11.2-23.3 m^3/s during May and June. Conductivity in the upper Salmon River drainage ranges from 37-218 mhos/cm (Emmett 1975).

Livestock grazing and hay production are the predominant uses of private land throughout the upper Salmon River basin. In localized areas, grazing within riparian zones has degraded aquatic habitat. Additionally, diversion of water from the river and its tributaries has impaired the production potential for chinook salmon and steelhead trout. Flow diversion from other tributary streams varies from partial to complete dewatering. Five major tributary creeks in the USR (Fourth of July Creek, Champion Creek, Fisher Creek, Williams Creek, and Beaver Creek) are completely dewatered on their lower ends during the summer and early fall. In 1992, most of the water rights to Busterback Ranch on the Salmon River between Alturas Lake Creek and Pole Creek were purchased with BPA mitigation funds. Until this time, the Busterback Ranch diversion at river kilometer 639 dewatered a section of the Salmon River during the summer and early fall in low to average water flow years.

In 1982, a water user along Pole Creek converted from flood irrigation to overhead sprinkler irrigation. This has decreased the withdrawal of water from Pole Creek. In 1983, the BPA funded the construction of a fish screen for the Pole Creek irrigation diversion. From 1985 to 1989, steelhead trout fry were outplanted into upper Pole Creek (IDFG, unpublished data). Additionally, as part of this project's research, adult chinook salmon were outplanted into Pole Creek in 1988-1990, and adult steelhead trout were outplanted in 1991.

The Sawtooth Fish Hatchery was constructed in cooperation with the U.S. Fish and Wildlife Service and the U.S. Army Corps of Engineers through the Lower Snake River Compensation Plan. The hatchery program involves trapping adult chinook salmon and steelhead trout and releasing smolts and other life stages. The hatchery is designed to produce 2.4 million chinook salmon smolts per year. Eyed steelhead trout eggs are sent to other facilities for rearing. The steelhead trout smolts are transported back to Sawtooth Hatchery for release. The objective is to release 4.5 million steelhead trout smolts at Sawtooth Hatchery.

Crooked River

Crooked River originates at an elevation of 2,070 m in the Clearwater Mountains within the Nez Perce National Forest and enters the South Fork Clearwater River at river kilometer 94 at an elevation of 1,140 m (Figure 2). The study area includes the entire Crooked River drainage. Historical chinook salmon and steelhead trout runs were eliminated in 1927 by the construction of Harpster Dam on the South Fork Clearwater River. Following removal of the dam in 1962, spring chinook salmon and B-run summer steelhead trout were reestablished in Crooked River. Other resident salmonids in the Crooked River drainage are native rainbow trout, cutthroat trout, bull trout, mountain whitefish, and nonnative brook trout (Petrosky and Holubetz 1986). Measured flows on Crooked River from 1991 through 1993 ranged from 0.373-6.88 m^3/s. Conductivity ranges from 29-39 μmhos/cm in flowing sections and 38-51 μmhos/cm in ponds were measured by Mann and Von Lindern (1987).

During the 1950's, dredge mining activities severely degraded habitat within the two meadow reaches of the stream. In the upstream meadow reach, the stream was forced to the outside of the floodplain. This resulted in a mostly straight, high gradient channel. In the lower meadow reach, dredge tailings have forced the stream into long meanders with many ponds and sloughs. During runoff, juvenile trout and chinook salmon use some of these ponds, but they are trapped as flows recede.

Fish density and habitat surveys were initiated in 1984 by IDFG and the Intermountain Forest and Range Experiment Station, U.S. Forest Service (USFS), Boise, Idaho. In 1984, in an effort to compensate for stream gradient and to increase the pool to riffle ratio, the USFS, with BPA funds, placed a series of log structures, rock and boulder deflectors, organic debris structures, and loose rock weirs in the upper meadow stream section. In addition, stream sides were stabilized and revegetated, an off-channel pond was connected with a side channel, and a culvert blocking adult passage was removed (Hair and Stowell 1986). Recent efforts have concentrated on connecting additional ponds in the dredge tailings to the main channel and developing side channels to provide continuous water supply during low flow periods.

Challis

After the Salmon River flows past the Sawtooth Hatchery area, it continues to travel in a north and east direction. About 118-144 km downstream of Sawtooth Hatchery, the river flows by Challis, Idaho. The Challis area is a fluvial valley located between semi-arid mountain ranges. The Salmon River enters the valley as a single channel and spreads out across the valley floor in several channels and then leaves the valley as a single channel. Livestock grazing and hay production are the major agricultural activities in this area.

Along the Salmon River, at several locations, rock weirs are built into the stream to divert water into irrigation canals. Most of the canals have had screens installed across them to prevent fish from traveling down the canals and into the fields. At the screens, bypass pipes are installed to carry the fish back to the Salmon River mainstream.

The S29 irrigation canal bypass pipe in the Challis area was selected for installation of a remote PIT tag monitor. The S29 fish screen is located on the west side of the river at river kilometer 525. The fish screen is located approximately 1.4 km downstream from its diversion weir.

METHODS

Study Area Structure

The upper Salmon River study area was divided into strata that were established during Idaho habitat enhancement studies (Petrosky and Holubetz 1986). Each stratum contained at least two study sites of approximately 100 m length of different habitat types (i.e. braided sections, side channels, or main channel). The study area began at river kilometer 617 and ended at river kilometer 656. Tributary streams within the study area were divided into strata and each stratum had at least two study sites.

The Crooked River study area also was divided into strata that were established during Idaho habitat enhancement studies (Petrosky and Holubetz 1986). In general, the strata were separated by habitat type. Off-channel ponds were included as separate strata. B-ponds were downstream of the Canyon stratum, and A-ponds were above the Canyon stratum (Figure 2). Relief Creek had two strata, and Five Mile Creek had one stratum.

Physical Habitat Surveys

The primary objectives of collecting physical habitat data were to determine the relationship between physical habitat and smolt production and to document changes in physical habitat over time. Physical habitat surveys were conducted using the Idaho ocular method (Petrosky and Holubetz 1987). This method used repeated measurements of established study sites. Within each study site, transects were established at 10 m intervals beginning at a randomly selected point. Stream width was measured at each transect. Water depth, water velocity, substrate composition, substrate embeddedness, and habitat type were measured or determined at the one-quarter, one-half, and three-quarter points of each stream transect. Water velocity was measured with a Marsh-McBirney or Price AA portable flow meter. Proportions of sand (0-0.5 cm diameter), gravel (>0.5-7.4 cm), rubble (>7.5-30.4 cm), boulder (>30.4 cm), and bedrock that comprise the substrate were estimated visually. Substrate embeddedness (the proportion of surface area of gravel, rubble, and boulder surrounded by sand) was estimated in 5% intervals from 0% to 100%. Characteristics described by Shepard (1983) were used to determine habitat types. Stream gradient was measured with a surveyor's transit and stadia rod. Gradient was calculated as the elevation difference between a study site's upper and lower boundaries divided by the study site's length. Stream channel type was classified according to Rosgen (1985). For future measurements and reference, all study sites were flagged and photographed.

Adult Escapements

Adult escapements for chinook salmon and steelhead trout in the USR and Crooked River were obtained from Sawtooth and Clearwater Fish Hatchery records, respectively. Except for the possibility of a small number of early adults which may have passed before weir placement or when weir panels were pulled because of high water flow, the entire escapement into the study areas consisted of fish that were trapped at the weir and released upstream to spawn naturally.

Adult Outplants

Upper Salmon River

The source of all adult chinook salmon and steelhead trout used for outplants in the USR was adults trapped at the Sawtooth Fish Hatchery weir. Adult steelhead trout were outplanted for carrying capacity research into the headwaters of the upper Salmon River.

In August, pairs of adult chinook salmon were outplanted into Frenchman Creek (Strata 2), Smiley Creek (Strata 1B), and Beaver Creek (Strata 2). A major factor in the selection of these outplant sites was the absence of natural reproduction as determined by our ground redd counts the previous year. Picket weirs were constructed to prevent the fish from moving above or below the release sites. Spawning activity was monitored on alternate days. Project personnel walked these sites every third day to observe spawning activity. Redds were counted, mortalities were measured for length, and female mortalities were examined for egg retention. Carcasses were measured (fork length) and cut open to confirm sex and determine completeness of spawning.

Crooked River

Adult steelhead trout for outplants into Crooked River came from the Crooked River adult trap. Adults were transported to release sites two at a time in a 120 liter cooler filled with water. Crooked River and outplant sites were walked several times to count redds and mortalities. Mid-eye to hypural plate length (MEH length) was measured on female mortalities and egg retention was estimated. Beginning in 1993, radio tags were placed in female adult steelhead and their movements were tracked. The radio tags were stomach implants with mortality signals. Fish were tracked daily to monitor movements and spawning activities.

Adult chinook salmon captured at the Crooked River trap were transported to the Red River facility and placed in a holding pond. When the adult chinook salmon from Crooked River became ripe, they were transported to Crooked River and released. Spawning activity in Crooked River was monitored on alternate days. Records were kept on observed spawning activity and redds and female mortalities were checked for egg retention.

Redd Counts and Estimated Egg Deposition

Aerial counts of steelhead trout redds were conducted by regional fisheries personnel in the USR and Crooked River. The aerial count for steelhead trout redds was conducted on May 10 for the USR and on May 11 for Crooked River. The aerial count for the USR steelhead trout redds was conducted from Sawtooth Hatchery weir upstream to Frenchman Creek, on Alturas Lake Creek from its mouth upstream to Alpine Creek, and on Pole Creek from its mouth upstream to the irrigation diversion at Valley Road. These were one-day peak counts via helicopter. The aerial steelhead trout redd count for Crooked River was conducted via helicopter from the town site of Orogrande downstream to the weir excluding the Canyon stratum.

Aerial counts of chinook salmon redds were conducted by regional fisheries personnel on September 1 for USR. No aerial counts were conducted on Crooked River.

In addition to aerial counts, project personnel conducted ground redd counts of the entire probable steelhead trout and chinook salmon spawning areas and adult outplant areas in USR and Crooked River. The counts were done in early May for steelhead trout and late August to early September for chinook salmon. The ground counts were done using guidelines identified by IDFG personnel (IDFG Redd Count Manual 1990), and data was reported in Riley (199-). All salmon carcasses found were measured (fork length and MEH) and cut open to confirm sex and completeness of spawning. Scale samples for aging and rearing site determination were collected from all carcasses found.

The numbers of effective female chinook salmon and steelhead trout spawning in the USR were estimated as the number of females released above the Sawtooth Fish Hatchery weir multiplied by prespawning survival observed at Sawtooth Fish Hatchery (Chapman 1993, Coonts 1993). The average fecundity for the females released above the weir was assumed to be the same as the average fecundity for those females taken into the Sawtooth Hatchery and spawned (Chapman 1993, Coonts 1993). Egg deposition for steelhead trout and chinook salmon was estimated as the number of effective female spawners multiplied by the average fecundity after adjusting fecundity for estimated egg retention.

Parr Abundance

Parr abundance by species and age class was estimated in both study areas. Streams in the study areas were divided into strata based on habitat types. Each stratum had at least two study sites. Visual counts were made in each study site by snorkelers. Densities (#/100 m^2) for each site were calculated using the visual counts and the surface area that the count encompassed. Snorkel counts were conducted in July for both study areas. Snorkel surveys were conducted in those streams that were dewatered by irrigation diversions if water was present in July. Total abundance of steelhead trout and chinook salmon parr was estimated by a multistage sampling design with visual estimation methods (Hankin 1986, Hankin and Reeves 1988).

August PIT Tagging

Chinook salmon and steelhead trout parr were Passive Integrated Transponder (PIT) tagged in their summer rearing areas during August in USR and Crooked River. Depending on site suitability and species available, fish were collected for PIT-tagging with a minnow seine or with a Smith-Root model 12 electrofisher. Seines were used primarily to sample low gradient sections for chinook salmon parr and the electrofisher was used primarily to sample high gradient sections for steelhead trout parr. The electrofisher was operated with a 30.5 cm diameter anode ring on a 2.0 m pole and a 2.4 m rattail cathode trailing behind. A voltage setting between 200 and 400 V was used due to low conductivities in the two systems. Pulse rates of 90 cycles/sec were used when fishing primarily for chinook salmon and 30 cycles/sec when fishing for steelhead trout. To reduce the incidence of electrical burn marks and fish mortality, nylon netting was tied completely around the anode ring. This modification did not appear to impair capture effectiveness.

When collecting parr with seines, a herder/driver technique was normally used. A snorkeler herded fish upstream until enough fish were concentrated above a suitable seine placement site. A bag or minnow seine was then placed across the stream downstream of the fish. The snorkeler then walked around the fish, got back into the stream, and drove the fish into the seine. This was a very effective method for most areas with adequate stream depth.

Tagging procedures included anesthetizing fish with MS-222 (buffered with sodium bicarbonate) and injecting PIT tags into the body cavity using a 12-gauge hypodermic needle and modified syringe (Kiefer and Lockhart 1995). Prior to use, PIT tags, needles, and syringes were sterilized by soaking in a 70% alcohol solution for at least 20 minutes. Syringes and needles were not re-used until they were resterilized.

After each tag was inserted, a loop style PIT tag detector was used to detect and send the tag codes to a battery powered laptop computer. The National Marine Fisheries Service (NMFS) has found that once a functional tag has been successfully implanted in a fish, the tag failure rate has been less than 1% (Prentice et al., 1986). Fork length was measured to the nearest 1.0 mm with a CalComp digitizer scale on all fish that were PIT tagged and all fish that were too small to tag (<55 mm for chinook salmon and <60 mm for steelhead trout). For most fish tagged, the weight was measured to the nearest 0.1 g on a Port-O-Gram balance. Perforated 1.0 m x 0.5 m x 0.7 m plastic tote boxes were used to hold fish before tagging, during recovery, and for 24-hour delayed mortality tests.

To determine 24-hour delayed mortality and tag loss, all tagged fish were held for 24 hours in the perforated plastic tote boxes in the stream sections where the fish were tagged. Tags were retrieved from any mortalities.

Emigration Trapping

To monitor fall and spring emigration of juvenile anadromous fish, we used floating scoop traps equipped with a 1.0 m wide inclined traveling screen (manufactured by Midwest Fabrications Inc., Corvallis, Oregon). The USR trap was located directly below the permanent weir at the Sawtooth Fish Hatchery. Water was funneled to the trap from a 3.1 m wide bay of the weir. The funnel was constructed of a picket weir with 3.8 cm spaces. To evaluate the spring emigration, the trap was operated continuously (except for breakdowns) from early March to mid-June. For fall emigration, the trap was operated from late August to early November.

On Crooked River, the trap was located 0.2 km above the mouth about 20 m below the adult trapping weir. A rock weir installed in 1990 helps direct fish into the trap. To evaluate the spring emigration, the trap operated from early March to mid June. For the fall emigration, the trap was operated from early September to early November.

All juvenile chinook salmon and steelhead trout juveniles captured were anesthetized and scanned with a PIT tag reader to determine if they had been previously tagged. All untagged juveniles (up to 100 per species and age group) were PIT tagged using the same procedures described previously. After tagging, these fish were held in perforated live boxes 300-400 m upstream of the trap. At dusk, the fish were released. Recaptures of these fish were used to calculate daily trap efficiency. Daily releases of PIT tagged juveniles for a particular species and age class were grouped until an average of eight recaptures would be expected in each group. The proportion recaptured in each group was assumed to represent trap efficiency. During the fall 1993 trapping season, stream flows did not change dramatically, and all of the grouped trap efficiency estimates were used to calculate a mean trap efficiency and 90% C.I. During the spring, we estimated a mean and 90% C.I. trap efficiency for different blocks of time (based on major changes in stream flow) during the trapping season.

The overall run estimates and 90% C.I. were obtained by summing the daily run estimates and recalculating confidence intervals. The daily run estimates were calculated by dividing the daily trap catches by the estimated trap efficiencies.

We used the fork-length frequency of the steelhead trout caught to estimate age composition of the steelhead trout emigrants. In the fall, steelhead trout parr <90 mm were considered fry, 90 mm to 124 mm were considered age-1+, and >124 mm were considered age-2+ and older. In the spring, steelhead trout <90 mm were considered age-1 parr, 90 mm to 129 mm were considered age-2 parr, and >129 mm were considered age-3 and older smolts.

Survival Rates

Estimates of the egg-to-parr survival (parr = age-0 for chinook salmon and age-1+ for steelhead trout) were calculated by dividing the parr population estimate by the estimated egg deposition that produced the parr.

The estimate of steelhead trout age-1+-to-age-2+ survival was calculated using PIT tag detection rates at the smolt collecting dams. For brood year 1990 steelhead trout, we divided the proportion of age-1+ parr PIT tagged in August 1991 and detected at the smolt collecting dams in spring 1993 by the proportion of age-2+ parr PIT tagged in August 1992 and detected at the smolt collecting dams in spring 1993.

We used PIT tag detection rates at the smolt collecting dams to estimate survival for both chinook salmon and steelhead trout. For the estimate of survival of parr PIT tagged in August that left the study area (includes overwinter survival or survival to the smolt stage), we divided the proportion of PIT tag detections at the lower Snake and Columbia rivers' smolt collecting dams of parr PIT tagged in August by the proportion of PIT tag detections at the dams of smolts PIT tagged during the spring emigration. We assumed that the groups being compared suffered the same tagging mortality and that smolts from both groups that survived to the dams were detected at the same rate. The equation for the estimate of August tagged parr was as follows:

$$S_{\text{Study Area}} = PTD_A / PTD_S$$

where:

PTD_A = Proportion of August PIT tagged parr detected at the dams
PTD_S = Proportion of spring PIT tagged smolts detected at the dams
$S_{\text{Study Area}}$ = Proportion of August parr surviving to smolts leaving the study area.

For a smolt estimate, we divided the PIT tag detection rate of summer parr or spring emigrants tagged in our study area by the detection rates of smolts that were PIT tagged at traps at the head of LGR pool. For these estimates, we assumed that LGR pool tagged fish were detected at the dams at the same rate as our tagged fish, that both groups suffered the same tagging mortality, and that both groups suffered the same migration mortality through LGR pool. The equation for the estimate of August tagged parr was as follows:

$$S_{\text{LGR pool}} = PTD_{\text{Study Area}} / PTD_{\text{LGR pool}}$$

where:

$S_{\text{LGR pool}}$ = the proportion of the study area PIT tagged parr or smolts surviving to head of Lower Granite Reservoir (LGR) pool
$PTD_{\text{Study Area}}$ = proportion of the study area PIT tagged parr or smolts detected at the dams
$PTD_{\text{LGR pool}}$ = proportion of LGR pool PIT tagged smolts detected at the dams

Remote Monitor

In mid-April, a PIT tag remote monitor was installed on the S29 irrigation diversion screen bypass pipe in the Challis, Idaho area. The monitor consisted of two parts. One part was a metal housing unit with a 4 foot long 6 inch diameter PVC pipe running through it. Surrounding the pipe were detector loops and exciter cards. The other part was a housing unit that contains a PIT tag recorder, a computer to store data, and a 12 volt battery connected to a variable amp charger. When a PIT-tagged fish was detected by the monitor, the tag code, date, and time were recorded on a computer file.

The efficiency of the monitor was tested weekly. The test consisted of releasing 20 PIT-tagged artificial fish (six inch neutrally buoyant high density plastic rod) directly into the entrance of the bypass pipe. The number of PIT tags detected by the monitor was divided by the number of test fish released into the bypass pipe. To estimate the proportion of PIT tagged emigrants passing through this stretch of the Salmon River that enter the irrigation canal, we released PIT-tagged emigrants 9 km upstream of the diversion on a weekly basis.

During the spring, the monitor was operated until smolt emigration appeared to be complete. For fall emigrations, the monitor was started mid-September. The monitor was removed in November after the irrigation diversion was closed for the winter season.

RESULTS

Upper Salmon River

Spring 1993 Emigration Trapping

In spring 1993 we operated a juvenile out-migrant trap on the USR to estimate smolt emigration for chinook salmon, *O. nerka*, and steelhead trout. We had planned to begin our trapping in the upper Salmon River during the first week of March; however, we did not receive our NMFS Section 10 permit from the National Marine Fisheries Service until April 2. This trap was operated continuously from April 3 to June 9 except for breakdowns of approximately two hours on the mornings of May 14 to May 17. We captured 165 chinook salmon smolts with an estimated trapping efficiency of 5.2% and 85 steelhead trout juveniles with an estimated trapping efficiency of 2.4%. We did not capture any emigrating *O. nerka* juveniles.

We estimated spring 1993 USR emigrations after April 2 of 3,173 chinook salmon smolts and 3,542 steelhead trout juveniles. Daily trap catches are shown in Figure 3. Age composition of the wild/natural steelhead trout emigrants was 27.1% (958) age-1, 49.4% (1,750) age-2, and 24.7% (875) age-3 and older smolts. Because of low numbers of recaptures for estimating trap efficiencies we were unable to calculate a confidence interval for these run estimates. We therefore urge caution in using these run estimates.

Using summer 1992 parr abundance estimates (Kiefer and Lockhart 1994) we estimated that 7.0% of the chinook salmon parr, 223.8% of age-1+ steelhead trout parr, and 191.0% of age-2+ and older steelhead trout parr emigrated in spring 1993 as smolts after April 2.

Spring 1993 Challis Remote PIT Tag Monitoring

In spring 1993 we operated a remote PIT tag monitor (monitor) on the fish bypass pipe at the S29 diversion fish screen to collect information on USR chinook salmon and steelhead trout smolt migration and survival. This monitor was operated from May 5 to June 2, 1993. We estimate this monitor detected 79% (90% C.I.; 61%-92%) of the PIT tagged test fish released directly into the entrance to the S29 bypass pipe. The actual number of fish detected was six chinook salmon and three steelhead trout. The Challis monitor detected 2.0% of the PIT tagged chinook salmon and steelhead trout smolts we released into the Salmon River 9 km upstream.

The monitor detected six PIT-tagged wild/natural spring chinook salmon smolts. Two of these chinook salmon smolts were tagged in August 1992 by our project in USR. One was tagged at our USR fall emigrant trap. The remaining three were tagged by the Shoshone-Bannock Tribe at their East Fork Salmon River emigrant trap in spring 1993. The monitor also detected two wild/natural steelhead trout smolts PIT tagged during spring 1993 at our USR trap and one wild/natural steelhead trout tagged in Fourth of July Creek during August 1992.

The Challis monitor also detected the following PIT-tagged hatchery steelhead smolts: 10 released April 9 at Sawtooth Hatchery and six released April 8 at the East Fork Salmon River adult trap. We estimated that, during the irrigation season in spring 1993, 2.5% (90% C.I.;

2.2%-3.3%) of the chinook salmon and steelhead trout smolts emigrating through this stretch of the Salmon River passed through the S29 bypass pipe.

To determine if the irrigation diversions in the Challis Valley were having a significant impact on the survival of smolts migrating through this stretch of the river, we made three releases of PIT-tagged smolts above and below the valley on May 12 and compared detection rates at the smolt collecting dams. For the one release group above the valley 49.0% were detected, and for the two release groups below the valley 63.7% and 61.5% were detected. A chi square test ($\chi^2 = 2.034$; $0.507 > P > 0.25$) indicates that there was no reduction in survival for those smolts released into the Salmon River above the Challis Valley as compared to those released below this valley.

Estimated Steelhead Trout Egg Deposition

In spring 1993, 1,591 (437 female) adult steelhead trout were captured at the Sawtooth Fish Hatchery Adult trap (Alsager, 1992). All seven wild/natural adults (four female) and 362 of the hatchery adults (75 female) were released immediately above the weir to spawn naturally. For our carrying capacity research, we transported and released 175 (55 female) hatchery adult steelhead trout into the Salmon River between Smiley Creek and Frenchman Creek between April 19 and May 3. On April 22, Sawtooth Hatchery personnel transported 60 (20 female) hatchery adults and released them into the Salmon River at the Blaine County Bridge.

On May 10, 1993, a steelhead trout redd count from a helicopter was conducted on the Salmon River from Sawtooth Hatchery weir to the mouth of Pole Creek. Twenty-one redds were observed between the weir and Hell Roaring Creek, three redds between Hell Roaring Creek and Alturas Lake Creek, and 12 redds between Alturas Lake Creek and Pole Creek.

Because of the difficulties in obtaining accurate counts of steelhead trout redds, we used the past five-year average of prespawning mortality observed at Sawtooth Fish Hatchery (5%) to estimate that 415 of the 437 females spawned in 1993. We used the brood year average fecundity observed by Coonts (1993) at Sawtooth Fish Hatchery (4,439) to estimate that 1,842,185 steelhead trout eggs were deposited in the USR in 1993 (Table 1).

The steelhead supplementation studies research project outplanted 22 (10 female) adult hatchery steelhead above a blocking weir on both Frenchman and Beaver creeks on April 29 and 30, 1993. On May 4, high water washed around the blocking weir on Beaver Creek. When Beaver Creek was walked on May 4, one steelhead adult and redd was observed 50 m downstream of the failed blocking weir. The blocking weir on Beaver Creek was expanded and five more pairs of adult steelhead were outplanted on May 6. A total of nine redds were observed in Frenchman Creek and five redds in Beaver Creek. We assumed that 9 of the original 10 female adult steelhead released into Beaver Creek spawned in the main Salmon River.

PIT Tag Detections

Detections of PIT tagged smolts at the lower Snake and Columbia rivers' smolt collecting dams provides information on chinook salmon and steelhead trout smolt migration characteristics. A negative correlation was found between travel time to LGR dam and smolt emigration date for both chinook salmon (r^2 = 0.43) and steelhead trout (r^2 = 0.63) (Figure 4). Mean smolt travel times to LGR dam and 90% confidence intervals were estimated to be 24.5 $\pm$ 2.1 days for chinook salmon (n = 27), and 20.0 $\pm$ 4.7 days for steelhead trout (n = 9).

The combined PIT tag detection rates at all Lower Snake and Columbia rivers' smolt collecting dams for smolts captured and PIT tagged at the USR emigrant trap in spring 1993 were 35.4% (56 of 158) for chinook salmon and 50.0% (9 of 18) for age-3 and older steelhead trout. The combined detection rate for wild/natural smolts PIT tagged by Buettner and Brimmer (1995) at their Snake River trap near Lewiston in 1993 was 61.4% for chinook salmon and 72.9% for steelhead trout.

For the fall 1992 USR emigrants, the detection rates were 6.7% (53 of 787) for chinook salmon and 14.3% (1 of 7) for age-2+ and older steelhead trout. Detection data for the August 1992 PIT tagged parr were summed by strata (Table 2). The combined detection rate for USR August 1992 PIT tagged parr was 8.2% (188 of 2,295) chinook salmon and 8.0% (4 of 50) age-2+ and older steelhead trout.

To determine if fish size had an effect on survival, we compared PIT tag detection rate and fish size for spring emigrants (Table 3). In spring 1993, no USR chinook salmon smolt length group had a significantly different detection rate (χ^2 = 0.677; 0.975 >P >0.95). We assume that most of the steelhead smaller than 130 mm will rear another year or more before smolting.

Parr Abundance

During the second half of July 1993, we conducted snorkel counts in established study sites of the USR to estimate densities and total abundance of chinook salmon and steelhead trout parr. Since the lower end of Champion Creek was not dewatered, we included it in our survey. For the USR, estimated total parr abundances with 90% confidence intervals were: 9,724 (3,008-16,440) age-0 chinook salmon, 4,251 (2,023-6,479) age-1+ steelhead trout, and 1,187 (627-1,747) age-2+ and older steelhead trout (Appendix A). Most of the estimated densities and total abundance of age-0 chinook salmon parr were the lowest we have observed since we began our intensive evaluation in 1987 (Table 4 and Appendix A). Also, most of the estimated densities and abundance of both age-1+, and -2+ and older steelhead trout parr were among the lowest observed since we began our intensive evaluation in 1987 (Tables 5 & 6, and Appendix A).

PIT Tagging

During the second half of August, we collected and PIT tagged representative groups of chinook salmon and steelhead trout parr in the USR. We PIT tagged 1,385 age-0 chinook salmon parr, and 342 steelhead trout parr. Due to the small populations, we did not tag our goals of 2,500 chinook salmon and 1,500 steelhead trout. Collecting, tagging, and 24-hour delayed mortalities for August PIT tagging totaled 4.9% (82) for chinook salmon parr, and 7.9% (34) for steelhead trout parr. Most of these mortalities (72 chinook salmon and 29 steelhead trout) occurred during one incident on August 6 when some of the perforated live boxes were placed in an eddy with insufficient water flow during a very hot day. We needed to collect 50-60 chinook salmon parr for NMFS (Robin Waples) electrophoretic analysis from this area and we discovered the mortalities early enough so that 63 of the chinook salmon could be used for this analysis.

The PIT tagged age-0 chinook salmon were divided into the following three different evaluation groups: Salmon River stratum 3 (477 tagged), Smiley Creek (514 tagged), and Frenchman Creek (263 tagged). We also collected 289 yearling chinook salmon in Frenchman Creek. We PIT tagged 124 of these Frenchman Creek yearling chinook salmon that did not look precocial and we believe may smolt in 1994.

The percentage and number of the different steelhead trout parr size groups PIT tagged were; 8% (27) <90 mm, 52% (178) 90-124 mm, and 40% (137) >124 mm.

Fall 1993 Emigration Trapping

During fall 1993, we operated a juvenile out-migrant trap on the USR to estimate chinook salmon and steelhead trout presmolt emigration. This trap was operated continuously from August 5 to November 8, 1993. We captured 101 chinook salmon presmolts with an estimated trapping efficiency of 2.4% and 82 steelhead trout juveniles with an estimated overall trapping efficiency of 2.3%. We were unable to calculate a confidence interval for fall 1993 chinook salmon and steelhead trout juvenile trap efficiency because of small sample sizes. We estimated total fall 1993 USR emigrations of 4,214 chinook salmon presmolts and 3,552 steelhead trout juveniles. Daily trap catches are shown in Figure 5. Because of the low numbers of fall emigrants captured and the low numbers of recaptures used to estimate total emigrations, we urge extreme caution in using these run estimates.

Age composition of steelhead trout emigrants based on trap captures was 61% (2,166) age-0, 9% (303) age-1+, and 30% (1,083) age-2+ and older. The estimated percentages of summer 1993 parr populations that emigrated in the fall were 45% for age-0 chinook salmon, 8% for age-1+ steelhead trout and 97% for age-2+ and older steelhead trout.

Fall 1993 Challis Remote PIT Tag Monitoring

In fall 1993, we operated a remote PIT tag monitor on the fish bypass pipe for the S29 diversion screen on the Salmon River near Challis, Idaho. This monitor was operated from August 30 to October 28, 1993.

This monitor detected 60.5% (90% C.I.; 35.6%-82.8%) of the PIT tagged test fish released directly into the entrance to the S29 bypass pipe. The monitor detected 4.4% (9 of 209) of the one PIT-tagged chinook salmon presmolt group released into the Salmon River 9 km upstream on October 14. We estimated that 7.3% (90% C.I.; 5.3%-12.4%) of the chinook salmon presmolts emigrating through this stretch of the Salmon River in fall 1993 during the irrigation season passed through the S29 bypass pipe.

On October 27, 1993 we released 28 PIT-tagged wild/natural chinook salmon presmolts into the S29 diversion 100 m upstream of the screen and bypass pipe. The monitor detected 64.3% (18) of these fish. We estimated that close to 100% of chinook salmon presmolts in the S29 canal immediately upstream of the screen passed through the bypass pipe. Because of only one test and small sample size we urge caution in using this data.

The monitor detected the following percentages of wild/natural chinook salmon parr PIT tagged in August upstream of Challis; East Fork Salmon River 1.2% (11 of 951), Valley Creek 0.5% (4 of 848), and 0.4% (2 of 541) of the wild/natural chinook salmon parr we PIT tagged in Frenchman Creek during August 1992. In addition, the monitor detected 2.8% (1 of 36) wild/natural chinook salmon PIT tagged and released at our USR emigrant trap during the period of time the monitor was operating, and 4.5% (6 of 132) of the wild/natural chinook salmon PIT tagged and released at the East Fork Salmon River trap.

Estimated Chinook Salmon Egg Deposition

In 1993, 376 (170 females) of the 587 adult chinook salmon captured at the Sawtooth Fish Hatchery adult trap were released above the weir to spawn naturally (Table 7).

During August 31 to September 1 a total of 127 chinook salmon redds were observed via ground counts, and 40 via helicopter counts in the entire probable natural spawning areas (Table 7).

Potential egg deposition in USR for brood year 1993 chinook salmon adults released above the hatchery weir to spawn naturally was estimated to be 613,918. The average fecundity in 1993 observed at Sawtooth Fish Hatchery for the same stock of chinook salmon was 5,007 eggs/female (Coonts 1993). We examined 17 post spawning female carcasses and estimated an average egg retention of 173 eggs/female.

Adult Chinook Salmon Outplants

On August 5 through September 2, 1993 we outplanted the following numbers of adult chinook salmon for our carrying capacity research; 16 females and 19 males into Frenchman Creek, 18 females and 22 males into Smiley Creek, and five females and six males into Beaver Creek.

We observed a total of six, 10, and five redds in the Frenchman Creek, Smiley Creek, and Beaver Creek outplant sites, respectively. We observed one instance of redd superimposition on one of the redds in Smiley Creek. We examined 11 post spawning female carcasses in Smiley Creek. Because we observed 10 redds and a superimposed redd and 11 carcasses, we believe that 11 females spawned successfully in Smiley Creek. We calculated an average egg retention of 169 eggs/female from 22 post spawning carcasses examined. We estimated 29,028 chinook salmon eggs were deposited in the Frenchman Creek adult outplant site, 53,218 in the Smiley Creek outplant site, and 24,190 in the Beaver Creek outplant site.

Survival Rates

The BY 1992 chinook salmon egg-to-parr survival for the headwaters of the Salmon River outplant was estimated to be 3.8% (Table 8). However, this estimate is known to be low, because we collected more age-0 chinook salmon in Smiley Creek for PIT tagging (555) than we estimate for a total population with snorkel counts (343). At best we collected one third of the population in Smiley Creek for PIT tagging, and if we use 1,665 as the chinook salmon population in Smiley Creek the headwater USR chinook salmon egg-to-parr survival would be 7.1%. For BY 1987-1992, the average chinook salmon egg-to-parr survival for the headwaters of the Salmon River averaged 20.6% (90% C.I.; 10.3%-33.3%). For the entire USR, we estimated BY 1992 chinook salmon egg-to-parr survival to be 4.8% (Table 9). For BY 1986-1992 the average chinook salmon egg-to-parr survival for the entire USR study area averaged 5.7% (90% C.I.; 3.6%-8.1%). Estimated BY 1992 steelhead trout egg-to-age-1+ parr survival rate for the entire USR was only 0.5%.

We estimated that parr-to-smolt (at the onset of smolt migration) overwinter survival in the USR was 23.2% for age-0 chinook salmon and 16.0% for age-2+ and older steelhead trout. For migration years 1989-1993, chinook salmon overwinter survival averaged 19.6% (90% C.I. of 17.5%-21.0%) and steelhead trout age-2+ and older overwinter survival averaged 26.6% (90% C.I.; 12.9%-43.0%).

The estimated survival, to the head of LGR pool, for parr PIT tagged in August 1992 was 13.4% for age-0 chinook salmon and 11.0% for age-2+ and older steelhead trout. For migration years 1988-1993, survival to the head of LGR pool for chinook salmon parr tagged in August averaged 8.7% (90% C.I.; 6.4%-11.5%). For presmolts PIT tagged during the fall 1992 emigration, the estimated survival to the head of LGR pool was 10.9% for age-0 chinook salmon, and 19.6% for age-2+ and older steelhead trout. For smolts PIT tagged during the spring 1993 smolt emigration, the estimated survival to the head of LGR pool was 57.7% for chinook salmon and 68.6% for steelhead trout. For migration years 1988-1993, the estimated survival for smolts leaving USR during the spring emigration averaged 47.9% (90% C.I.; 32.6%-66.3%) for chinook salmon and 39.8% (90% C.I.; 27.3%-53.1%) for steelhead trout age-2+ and older.

Physical Habitat

During 1993 in the upper Salmon River (USR) study area, a physical habitat survey was conducted by project and regional personnel on 18 study sites. In the Crooked River study area, physical habitat surveys were conducted by project personnel on nine study sites. Project data have been entered into the IDFG physical habitat database. The management of this database is handled by the Idaho Habitat Evaluation for Off-Site Mitigation Record project and is reported in Leitzinger and Petrosky (in progress).

RESULTS

Crooked River

Spring 1993 Emigration Trapping

In spring 1993, we operated a juvenile out-migrant trap on Crooked River to estimate smolt emigration for chinook salmon and steelhead trout. This trap was operated continuously from March 13 to June 9, 1993. We captured 100 chinook salmon smolts with an estimated trapping efficiency of 57.0% (90% C.I.; 43.9%-69.4%). We also captured 231 steelhead trout juveniles with an estimated trapping efficiency of 17.3% (90% C.I.; 14.5%-20.5%).

We estimated total spring emigrations of 170 (90% C.I.; 140-220) chinook salmon smolts and 1,335 (90% C.I.; 1,127-1,593) steelhead trout juveniles. Age composition of the steelhead trout juvenile emigrants was estimated to be 35.5% (474) age-1, 28.6% (381) age-2, and 35.9% (480) age-3 and older smolts. As in past years, peaks in both chinook salmon and steelhead trout emigration from Crooked River corresponded with increases in discharge (Figure 6).

Estimated Steelhead Trout Egg Deposition

In 1993, 48 adult steelhead trout (24 males and 24 females) were captured at the Crooked River adult trap. The first fish was trapped on April 15 and the last fish on May 7. Sixteen of the adults captured (nine males and seven females) were wild/natural fish and were released immediately upstream of the weir. The remaining 32 adults (15 males and 17 females) were sacrificed and donated to charity.

The lengths of all wild/natural steelhead trout adults were measured, scale samples were taken, and PIT tags were injected into the isthmus. In addition, a stomach implant radio tag was orally inserted into all females released above the weir.

One of the female adult steelhead trout was found on the ground beside the adult trap. Apparently, she had recently jumped from the trap holding box. After we revived this female, we radio tagged and released her above the weir. This fish moved into the first pool above the adult trap and stayed there during the next day. On the second day after we released this female, we found the radio tag on the bank just upstream of the weir. The tag had teeth marks on it. We believe this fish died from the stress of jumping out of the trap and laying on the ground for an unknown amount of time and that an otter ate the carcass after she had died.

Of the other six adult female steelhead trout radio tagged and released above the weir, we observed four on redds. The fifth female was believed to have spawned during a period when the water was too high and turbid to observe. The radio tag was giving off an intense activity signal similar to the signal when other females were observed spawning. The remaining female regurgitated her radio tag soon after release and we never saw her again. Our best guess is that this female successfully spawned, but we do not know for sure. In addition, on May 27, a wild/natural female steelhead trout carcass (75 cm) was found on the weir. This female had no scar on its isthmus where we PIT tagged all adults before we released them. This female apparently moved into Crooked River during one of the periods when the weir was out due to high water. This female had only four eggs retained and had apparently spawned successfully.

Our best estimate is that seven adult female steelhead trout successfully spawned in Crooked River with an average egg retention of four eggs. The average fecundity for B-run steelhead trout observed at Dworshak Nation Fish Hatchery in 1993 was 4,321 eggs/female. From this information we estimate that 30,247 steelhead eggs were successfully deposited in Crooked River in 1993.

PIT Tag Detections

Detections of PIT tagged smolts at lower Snake and Columbia rivers' smolt collection facilities provide information on chinook salmon and steelhead trout smolt migration characteristics. A negative correlation was found between travel time to LGR dam and smolt emigration date for both chinook salmon (r^2 = 0.62) and steelhead trout (r^2 = 0.58) (Figure 7). For any given date of emigration from Crooked River, chinook salmon smolts on average take longer to get to LGR dam than steelhead trout smolts. Mean smolt travel times with 90% C.I. to LGR dam were estimated to be 46.0 ± 6.6 days for 31 chinook salmon and 19.2 ± 3.8 days for 55 steelhead trout.

The combined PIT tag detection rates at all the lower Snake and Columbia rivers' smolt collection facilities for smolts captured, PIT tagged, and released at the Crooked River emigrant trap in spring 1993 were 56.1% (55 of 98) for chinook salmon, and 79.5% (66 of 83) for age-3 and older steelhead trout. For the fall 1992 Crooked River emigrants, the detection rates were 25.8% (25 of 97) for chinook salmon and 32.8% (61 of 186) for age-2+ and older steelhead trout. Detection data for the August 1992 PIT tagged parr were summed by strata where the fish were captured, tagged, and released (Table 10). The combined detection rates for Crooked River parr PIT tagged in August 1992 were 7.7% (29 of 379) for chinook salmon and 16.6% (87 of 525) for age-2+ and older steelhead trout. The combined detection rate for wild/natural smolts PIT tagged by Buettner and Brimmer (1995) at their Clearwater River smolt trap in 1993 was 73.8% for chinook salmon and 86.3% for steelhead trout.

Parr Abundance

During the first half of July 1993, we conducted snorkel counts in established study sites on Crooked River to estimate densities and abundance of chinook salmon parr and steelhead trout parr. Estimated total parr abundances with 90% confidence intervals were: 24,435 ± 14,835 age-0 chinook salmon, 2,697 ± 734 age-1+ steelhead trout, and 3,169 ± 851 age-2+ and older steelhead trout (Appendix B).

Chinook salmon parr densities were the highest we have estimated since 1989 (Table 11). Steelhead trout age-1+ parr densities were among the lowest we have observed in Crooked River (Table 12). Densities of age-2+ and older steelhead trout parr were within the mid range of what we have observed since we began our research in 1987 (Table 12).

PIT Tagging

During the first half of August, we collected and PIT tagged representative groups of chinook salmon and steelhead trout parr. We PIT tagged a total of 1,990 age-0 chinook salmon, and 745 steelhead trout parr. The age composition of steelhead trout parr PIT tagged was 0.4% (3) age-0, 36.4% (271) age-1+, and 63.2% (471) age-2+ and older. Combined collecting, PIT tagging, and 24-hour delayed mortalities for August PIT tagging were 1.2% (27) for age-0 chinook salmon, and 0.5% (4) for steelhead trout parr.

We PIT tagged age-0 chinook salmon and age-2+ and older steelhead trout in each of four different evaluation groups. For age-0 chinook salmon, we PIT tagged the following evaluation groups: upper meadow section (613 tagged), canyon section (599 tagged), lower meadow main channel (408 tagged), and lower meadow connected ponds (370 tagged). For age-2+ and older steelhead trout we PIT tagged the following evaluation groups: stratum 1 (101 tagged), stratum 2 (93 tagged), canyon section (190 tagged), and lower meadow section (87 tagged).

Fall Emigration Trapping

During fall 1993, we operated a juvenile out-migrant trap on Crooked River to estimate chinook salmon and steelhead trout presmolt emigration. This trap was operated continuously from August 20 to November 3, 1993. We captured 368 chinook salmon presmolts with an estimated trapping efficiency of 5.5% (90% C.I.; 3.4%-8.1%) and 23 steelhead trout juveniles with an estimated trapping efficiency of 9.1%. Because we captured so few steelhead trout juveniles, we were unable to calculate confidence intervals for steelhead trout trap efficiency. We estimated that 6,691 (90% C.I.; 4,543-10,824) chinook salmon presmolts and 253 steelhead trout juveniles emigrated from Crooked River. All 23 steelhead trout juveniles we captured were age-2+ or older based on their fork length (>124 mm).

The estimated percentages of the Crooked River 1993 summer parr populations that emigrated in the fall were 27% of the age-0 chinook salmon, 0% of the age-1+ steelhead trout, and 8% of the age-2+ and older steelhead trout.

In fall 1993, both chinook salmon and steelhead trout juveniles had similar peaks of emigration from Crooked River (Figure 8). These peaks of fall 1993 emigration corresponded with decreases in water temperature (Figure 9).

Estimated Chinook Salmon Egg Deposition

In 1993, 102 (50 females) of the 402 adult chinook salmon captured at the Crooked River adult trap were released above the weir to spawn naturally. In addition, on August 20, 30 adult chinook salmon (15 females), and on August 27, 20 adult chinook salmon (10 females) captured at Crooked River and held at the Red River Hatchery were released back into Crooked River at the South end of the Orogrande airstrip after ripening. Stomach implant radio tags were orally inserted into all 25 of these females.

Of the 25 females radio tagged, eight regurgitated their tags. Three of the females that regurgitated their tags did so while building their redds, so they were known to be successful spawners. Of the other five females that regurgitated their tags, we do not know how many successfully spawned. However, we observed some untagged female chinook salmon spawning in the airstrip area. We believe that the five females who regurgitated their tags spawned successfully.

All of the radio tagged females (17) that did not regurgitate radio tags built redds and spawned. However, in 14 of these females the radio tag broke through the intestinal tract and interfered with complete egg deposition. The females whose radio tags did not break through their intestinal tract had an average egg retention of three (n = 40). Those females whose radio tags did break through their intestinal tract had an average egg retention of 671 (n = 14).

During September 8-10, a total of 54 chinook salmon redds were observed via ground counts (this includes the 20 redds discussed above). We found 13 female carcass without radio tags during the redd counts and observed an average egg retention of three eggs in these females. The average fecundity for female chinook salmon captured at Crooked River and spawned at the Red River Hatchery was 4,766 (McGehee et al 1993). Based on previous years results (Kiefer and Lockhart, 1994) we assumed a redd:female spawner ratio of 1:1. To estimate the number of chinook salmon eggs successfully deposited in Crooked River, we divided the number of redds observed into two groups. The first redd group consisted of the 14 redds from females who had radio tags break through their intestinal tract and who had an average egg retention of 671 eggs [(4,766 - 671) X 14 = 57,330]. The second redd group consisted of the 40 redds observed from females where the radio tags did not break through their intestinal tract and who had an average egg retention of three eggs [(4,766 - 3) X 40 = 190,520]. We estimate a total chinook salmon egg deposition of 57,330 + 190,520 = 247,850 (Table 13).

Survival Rates

The BY 1992 chinook salmon egg-to-parr survival rate for Crooked River was estimated to be 11.9%. For BY 1989-1992, the average chinook salmon egg-to-parr survival for Crooked River was 12.7% (90% C.I.; 9.6%-16.0%). The estimated BY 1992 steelhead trout egg-to-age-1+ parr survival rate for Crooked River was only 1.3%.

We estimated the BY 1991 steelhead trout age-1+-to-age-2+ parr survival for Crooked River to be 23.5%. This estimate was made by dividing the 1993 detection rate at the smolt collection facilities for age-1+ steelhead trout parr tagged in August 1991 [0.039 (60 of 1,541)] by the 1993 PIT tag detection rate for age-2+ steelhead trout parr tagged in August 1992 [0.166 (87 of 525)].

We estimated that parr-to-smolt (at the onset of smolt migration) overwinter survival in Crooked River was 13.7% for age-0 chinook salmon and 20.9% for age-2+ and older steelhead trout. For migration years 1989-1993, this overwinter survival estimate averaged 20.9% (90% C.I.; 10.7%-33.5%) for chinook salmon and 40.6% (90% C.I.; 24.2%-58.1%) for steelhead trout. The estimated survival to the head of LGR pool for parr PIT tagged in August 1992, was 10.4% for age-0 chinook salmon and 19.2 % for age-2+ and older steelhead trout. For migration years 1989-1993, this August parr to the head of LGR pool averaged 11.3% (90% C.I.; 5.3%-19.1%) for chinook salmon. For presmolts PIT tagged during the fall 1992 emigration, the estimated survival to the head of LGR pool was 35.0% for age-0 chinook salmon and 38.0% for age-2+ and older steelhead trout. For smolts PIT tagged during the spring 1993 out-migration, the estimated survival to the head of LGR pool was 76.0% for chinook salmon and 92.1% for steelhead trout. For migration years 1989-1993, this smolt migration survival estimate to LGR pool averaged 55.4% (90% C.I.; 35.6%-66.9%) for chinook salmon and 71.7% (90% C.I.; 53.5%-86.9%) for steelhead trout.

DISCUSSION

Spring Emigration Trapping

Low chinook salmon population levels in the USR and the low trap efficiency of our USR emigrant trap have resulted in our inability to capture enough chinook salmon emigrants for our analyses. This has resulted is our inability to accurately and precisely estimate the run sizes. Also, we do not get enough PIT tag detections at the smolt collecting facilities for run timing or survival estimates. With the better chinook salmon adult escapement in 1993, we should be able to make good estimates during the fall 1994 and spring 1995 emigrations. However, the poor adult chinook salmon escapements projected for 1994 and 1995 indicate that we will have difficulties once again collecting enough chinook salmon emigrants from these brood years for analysis. We propose operating a second trap in series with the current USR emigrant trap. Besides approximately doubling our trapping efficiency and the number of emigrants captured for PIT tagging, this second trap would have other benefits. First, it will be better statistically to operate two traps in series than one trap alone. Second, we would no longer need to release PIT tagged fish back upstream to estimate trap efficiency. We plan on beginning to operate a second trap in fall 1995.

Spring Challis Remote PIT Tag Monitoring

During 1993 (a more normal water flow year) we estimated that only 2.5% of the chinook salmon and steelhead trout smolts emigrating through the Challis Valley in the Salmon River during the irrigation season passed through the bypass pipe of the S29 irrigation diversion. In 1992 (a very low water year) we estimated that 9.5% passed through this bypass pipe (Kiefer and Lockhart 1994). Our limited data indicates that in 1992 there may have been some reduction in survival for smolts released above the Challis Valley as compared to those released below this valley (Kiefer and Lockhart 1994); in 1993 we observed no significant difference. In 1992 the flows in the Salmon and Snake rivers were low and dropping drastically during the course of our study. Estimated survival of smolts released in the same location on a weekly basis for our study in 1992 showed dramatic reduction in survival as the season progressed (Kiefer and Lockhart 1995). It is very possible the reduction in survival we detected in 1992 for the smolts released above the Challis Valley as compared to those released below was caused by the longer time it took them to get to the collection facilities. We estimate that on average 70% of the chinook salmon smolt migration will be past the Challis Valley before the irrigation season begins. Therefore, our data indicates that at most the irrigation diversions in the Challis Valley slightly impact the survival of the tail end of the chinook salmon smolt migration during low flow years. This suggests to us that the irrigation diversions on the Salmon River are not a significant cause for the decline of Salmon River chinook salmon. This data is very limited and should be viewed with extreme caution.

PIT Tag Detections

In 1993 PIT tag detection rates for chinook salmon parr PIT tagged in August 1992 from upstream areas of USR had significantly higher detection rates (X^2 = 88.76; P <0.001) than those tagged from lower USR locations (Table 2). We hypothesize that either the upstream areas had better overwintering habitat, and/or chinook salmon in lower USR areas suffered some other factor unknown to us that affected the survival of the lower USR locations. The fall 1992 chinook salmon emigrants PIT tagged during September and October had a lower detection rate than the average August 1992 PIT tagged chinook salmon parr. This indicates to us that the fall 1992 emigrants were comprised mostly of fish from lower USR areas. We know that a dewatered stretch on the Salmon River prevented the parr from Frenchman Creek from emigrating in fall 1992.

We compared the arrival timing at LGR dam for chinook salmon PIT tagged in lower USR areas and the upstream areas (Figure 10). From past years' analysis of PIT tag detection data (Kiefer 1992), we have found that the fall emigrants from a particular study area arrive earlier at LGR dam than those that overwinter in the study area. This suggests to us that a higher percentage of chinook salmon parr from Frenchman Creek and Alturas Lake Creek overwinter in the study area and had higher overwinter survival than those from lower USR areas.

For migratory years 1990-1993 we compared detection rates of August PIT-tagged parr to determine if method of capture (seine or electrofisher) had a significantly different detection rate for either age-0 chinook salmon or age-2+ and older steelhead trout. Of the 11 comparisons we were able to make (Table 14), only age-2+ and older steelhead trout PIT tagged in August 1989 from Crooked River (Crooked River) showed a significant difference (X^2 = 5.818; 0.025 > P >0.01) between methods of capture. This suggests that normally after a chinook salmon or steelhead trout parr is successfully PIT tagged, there is no significant difference in survival to the smolt collection facilities whether it was collected with a seine or an electrofisher.

Steelhead Trout Parr Growth

Steelhead trout parr in USR stratum 9 appear to grow very well. Of the 258 steelhead trout parr we PIT tagged in stratum 9 of the Salmon River, 99 had fork lengths greater than 124 mm. We normally use 125 mm as the smallest fork length for age-2+ steelhead trout during our August PIT tagging. We believe the majority (if not all) of these 99 larger steelhead trout we PIT tagged in stratum 9 were actually age-1+ fish produced from the 395 (97 female) adult hatchery steelhead trout outplanted to this area in 1992. This belief is based on the very low population of age-1+ steelhead trout we observed in this area of USR in 1992 (Kiefer and Lockhart, 1994), and that we recaptured in 1993 five of the age-0 steelhead trout we PIT tagged in this stratum in 1992 and they ranged in fork lengths between 116 and 150 mm with three of them being larger than 124 mm.

Estimated Chinook Salmon Egg Deposition

We encountered difficulties using stomach implant radio tags to estimate chinook salmon egg deposition. Fourteen of the 25 female adult chinook salmon we radio tagged had their tag break through their intestinal tract. This seemed to occur late in the spawning process because none of these females showed signs that anything was wrong until after the redd was constructed. We hypothesize the tag broke through the stomach during either redd construction or egg deposition. These 14 females had a much higher average egg retention (671) than the other 40 females examined (3).

We did not observe this implant radio tag expulsion from the stomachs of the female adult steelhead trout in which we inserted these tags. We hypothesis that the reason for these different results is caused by the major difference in life history between chinook salmon and steelhead trout. All chinook salmon die soon after spawning, while steelhead trout can survive and spawn several times. We believe that associated with this predetermined dying, the intestinal tract of adult chinook begins to break down, and the action of these females digging a redd and/or spawning pushed the tag through their intestinal tract. Once the tag was through the intestinal tract it appeared to block the females vent sometime during egg deposition.

We plan to continue to use these tags to help us estimate steelhead trout egg deposition but not chinook salmon egg deposition.

Survival Rates

Estimated BY 1992 chinook salmon egg-to-parr survival was among the lowest we have estimated for both the USR headwaters (7.1%) and the entire USR (4.8%). We hypothesize that the amount of anchor ice formation is the major factor in the variation we have observed in USR chinook salmon egg-to-parr survival (Tables 12 and 13). 1992 was a severe drought year, and the stream flow levels in the USR were very low going into the winter. The winter of 1993 was fairly cold, and there was not a lot of precipitation until late in the winter. We believe these factors resulted in a large amount of anchor ice formation, which crushed many of the chinook salmon eggs or alevins in the gravel.

Estimated BY 1992 chinook salmon egg-to-parr survival for Crooked River (11.9%) was within the range we have estimated there in the past (9.4%-15.0%). The lower elevation and wetter climate in Crooked River would result in much less anchor ice formation as in USR.

Estimated chinook salmon egg-to-parr survival for USR BY 1986-1992 averaged 5.7% (90% C.I.; 3.6%-8.1%), for headwaters USR BY 1987-1992 averaged 20.6% (90% C.I.; 10.3%-33.3%), and for Crooked River BY 1989-1992 averaged 12.7% (90% C.I.; 9.6%-16.0%). In 1991, Peery and Bjorn (1992) estimated that approximately 55% of the juvenile chinook salmon in the USR emigrated from the study area as fry. If we assume that approximately 55% left in each year on average, and we adjust our egg-to-parr survival estimates accordingly, we then estimate USR BY 1986-1992 chinook salmon egg-to-parr survival averaged 12.7%.

RECOMMENDATIONS

1. We found that using stomach implant radio tags on adult females works well for estimating steelhead trout egg deposition but not for chinook salmon. Because we observed a high incidence of the radio tag interfering with complete egg deposition in chinook salmon, we recommend against using this type of tag on adult female salmon.

2. We recommend the funding of a graduate research project to determine if PIT tag mark/recapture data on another method can be used to more accurately and precisely estimate juvenile anadromous fish populations than our current snorkel count methodology.

ACKNOWLEDGEMENTS

We would like to extend our thanks to the following people who assisted us with this report.

Steven Warren, Paul Bunn, Scott Olson, James Asher, Vincent Pero, Allison Titus, Chris Murphy, and Steve Doughty helped collect field data, enter the data into the computers, and analyze the data. Tom Schill assisted with data analysis and getting equipment into the field. Shannon Winsor assisted with data analysis.

Joe Chapman and his staff at the Sawtooth Fish Hatchery and Jerry McGehee and his staff at the Clearwater Fish Hatchery provided technical information, manpower assistance, use of equipment, and housing for our trap tenders.

Dave Cannamela and Dean Rhine with the Lower Snake River Compensation Hatchery program assisted us with our PIT tagging operations in the upper Salmon River. Alan Byrne, Brett Pike, Gary Tanner, Heidi Howard, and Paul McArthy with the Steelhead Supplementation program assisted with snorkeling and PIT tagging in the upper Salmon River and Crooked River.

Tom Curet, John Conway, Sherman Sprague, Ken Vaughn, and Tom Kendall with the Idaho Fish and Game, Salmon Regional Office helped with snorkeling and PIT tagging in the upper Salmon River.

The Nez Perce National Forest allowed us to use a Forest Service cabin while collecting data on Crooked River.

Sherman Sprague, Bill Stutz, and Michael Weston with IDFG assisted with ground redd counts on the upper Salmon River; and Mark Liter and Tom Curet (IDFG) conducted the aerial redd counts for steelhead.

Jim Blake and staff IDFG Salmon assisted with installation and operation of the remote PIT tag monitors in the Challis Valley.

A special thanks to Barbara Dunn, our staff technical typist, who assisted us with all the project administration.

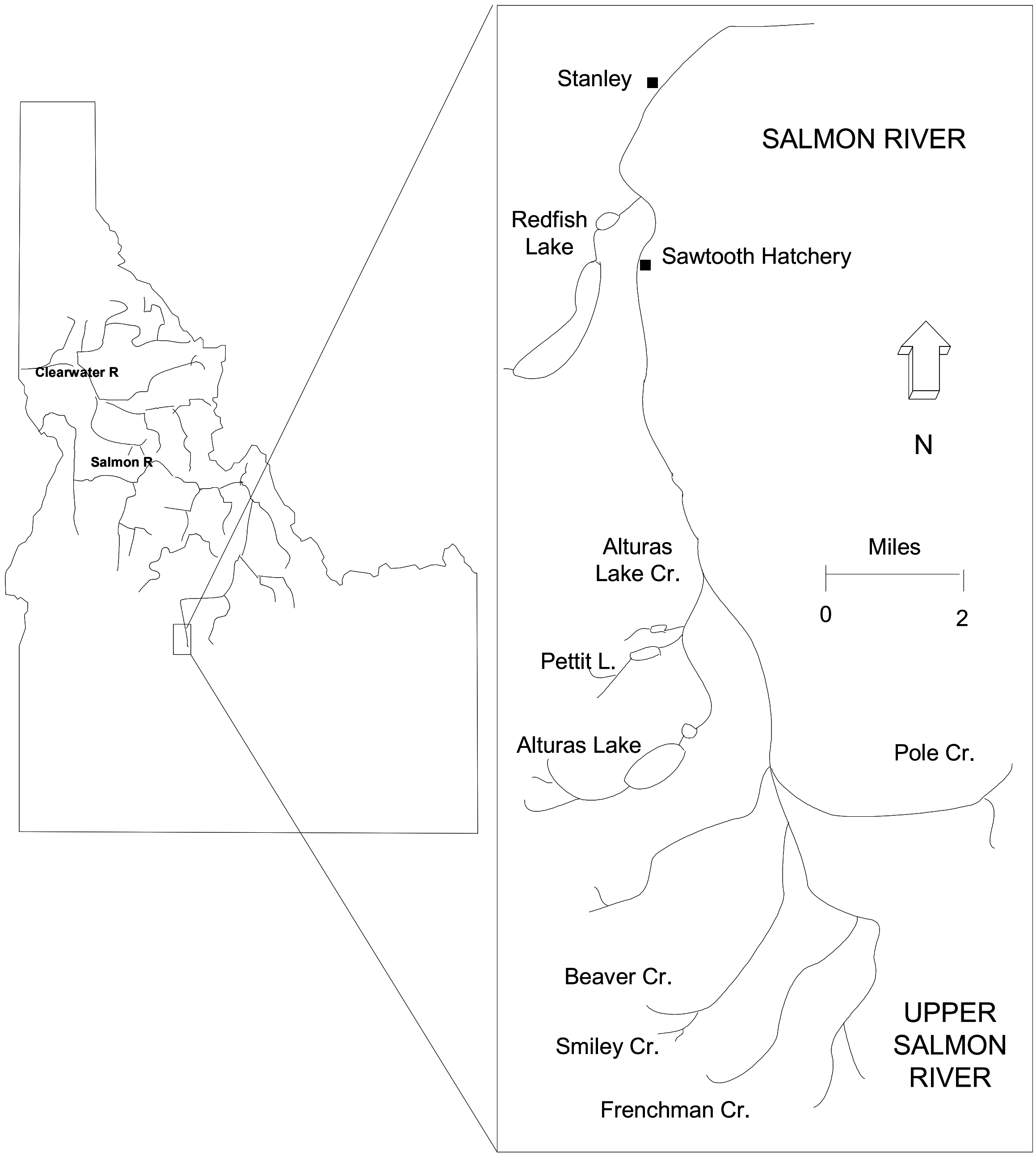

Figure 1. Location of upper Salmon River study area.

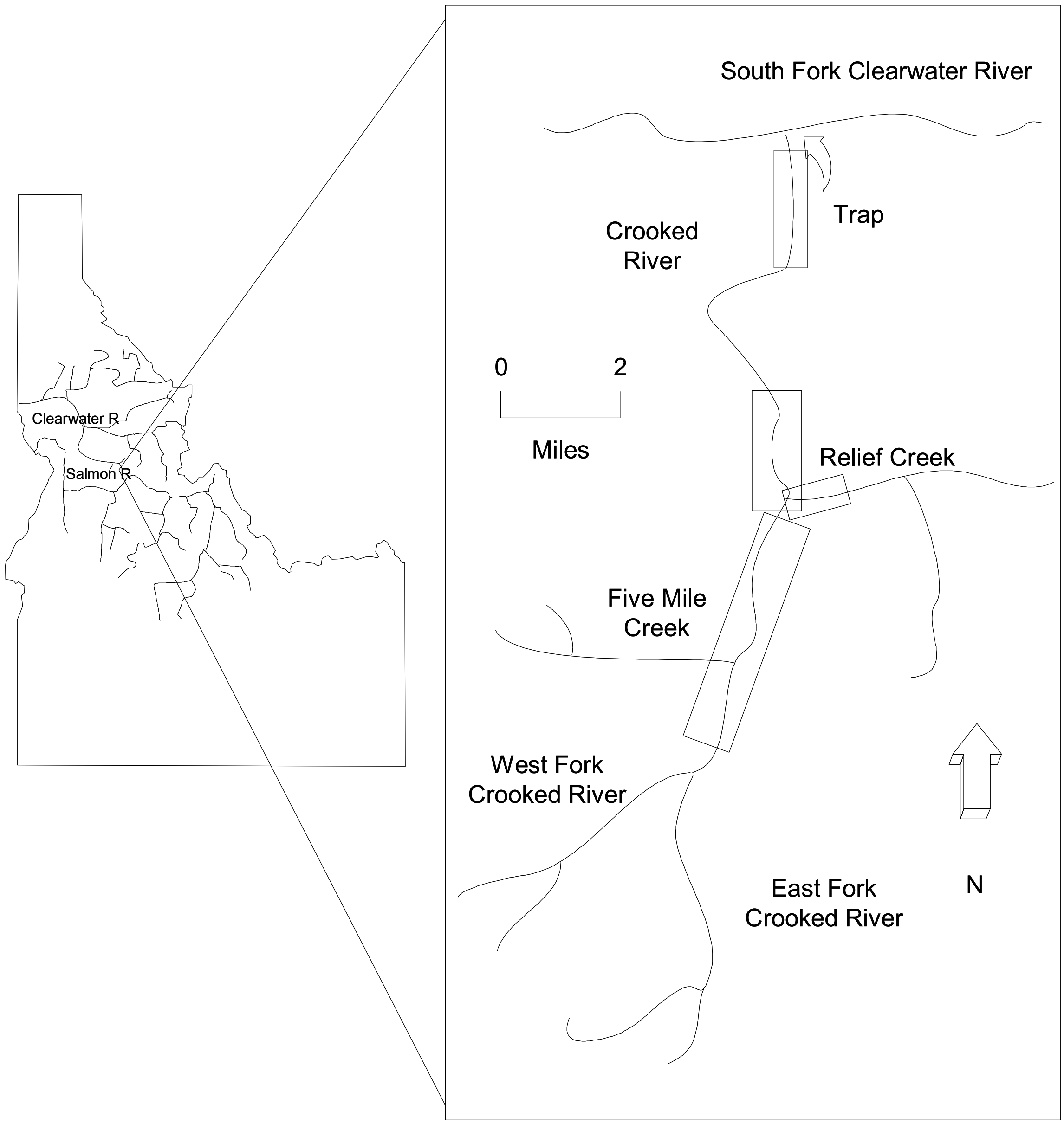

Figure 2. Location of Crooked River study area. Dredged areas are boxed.

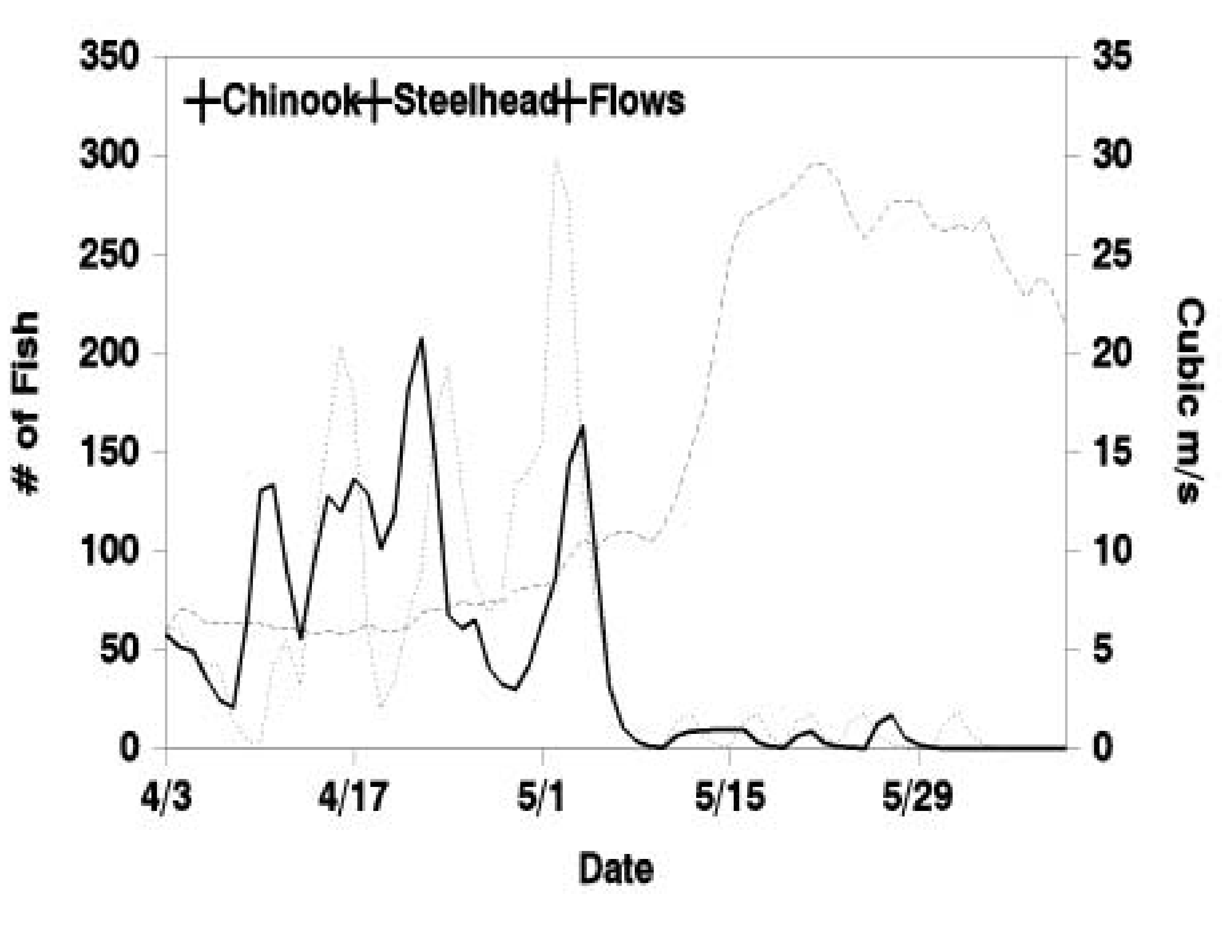

Figure 3. Spring 1993 upper Salmon River chinook salmon and steelhead trout emigration timing (3-day moving average).

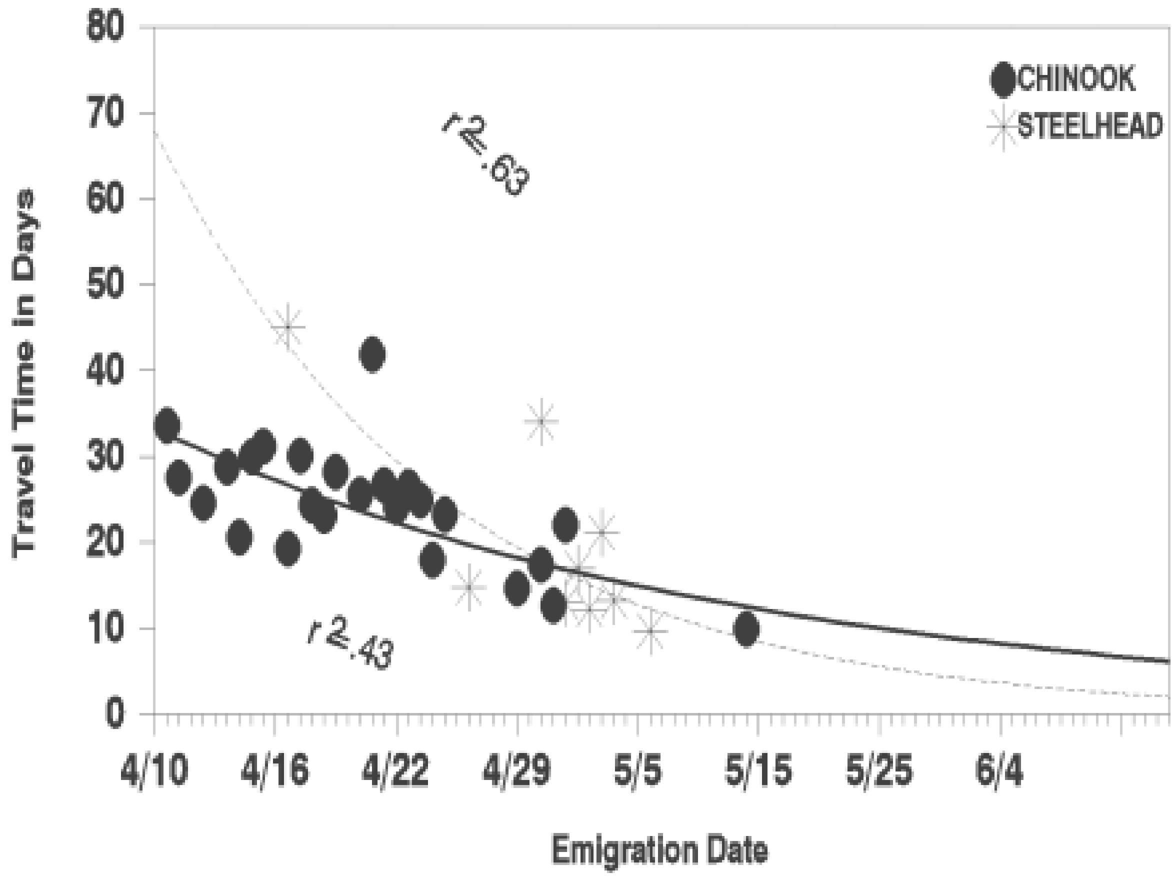

Figure 4. Travel time to Lower Granite Dame versus emigration date for chinook salmon and steelhead trout captured, tagged, and released at the upper Salmon River trap, spring 1993.

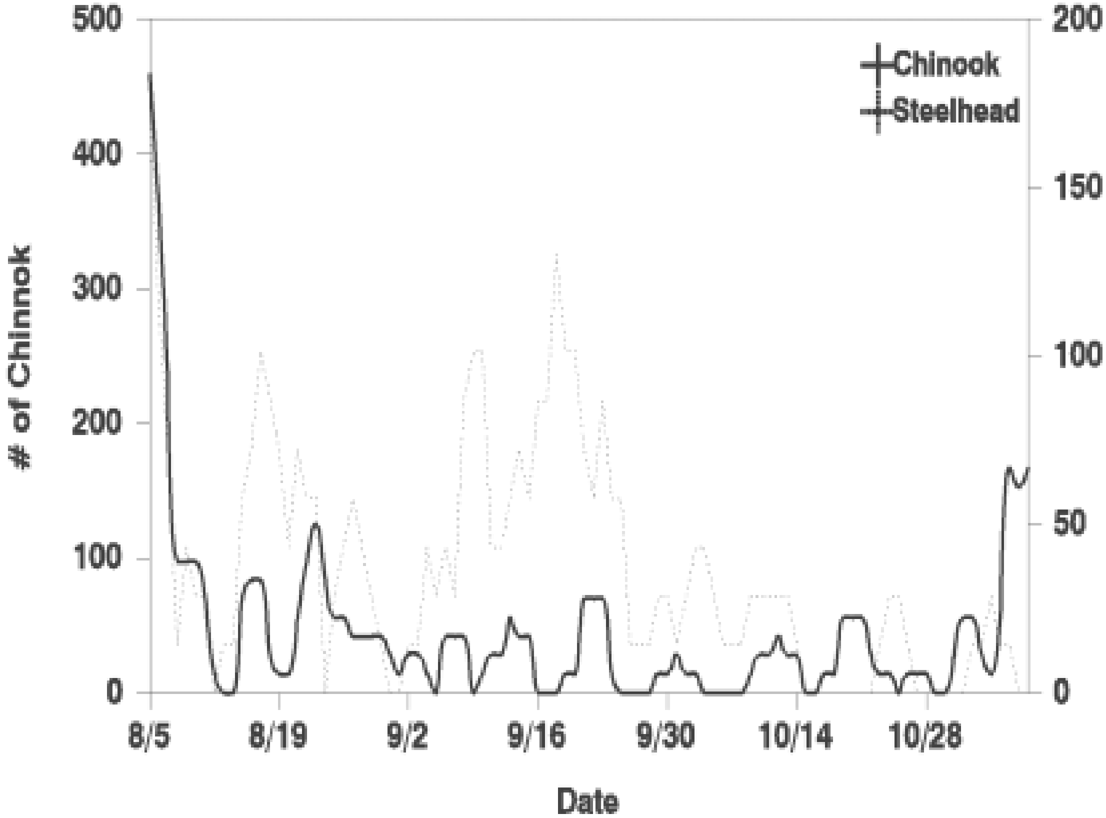

Figure 5. Fall 1993 upper Salmon River chinook salmon and steelhead trout emigration timing (3-day moving average).

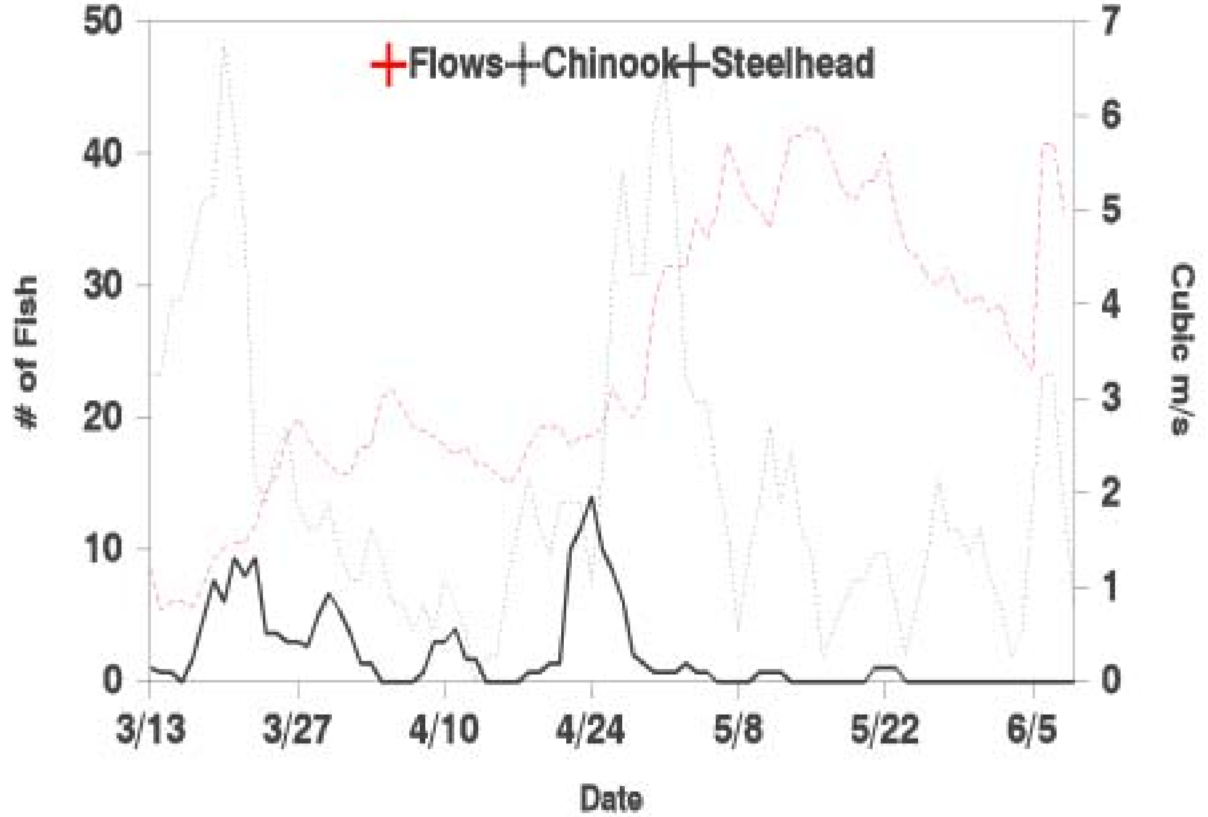

Figure 6. Spring 1993 Crooked River chinook salmon and steelhead trout emigration timing (3-day moving average).

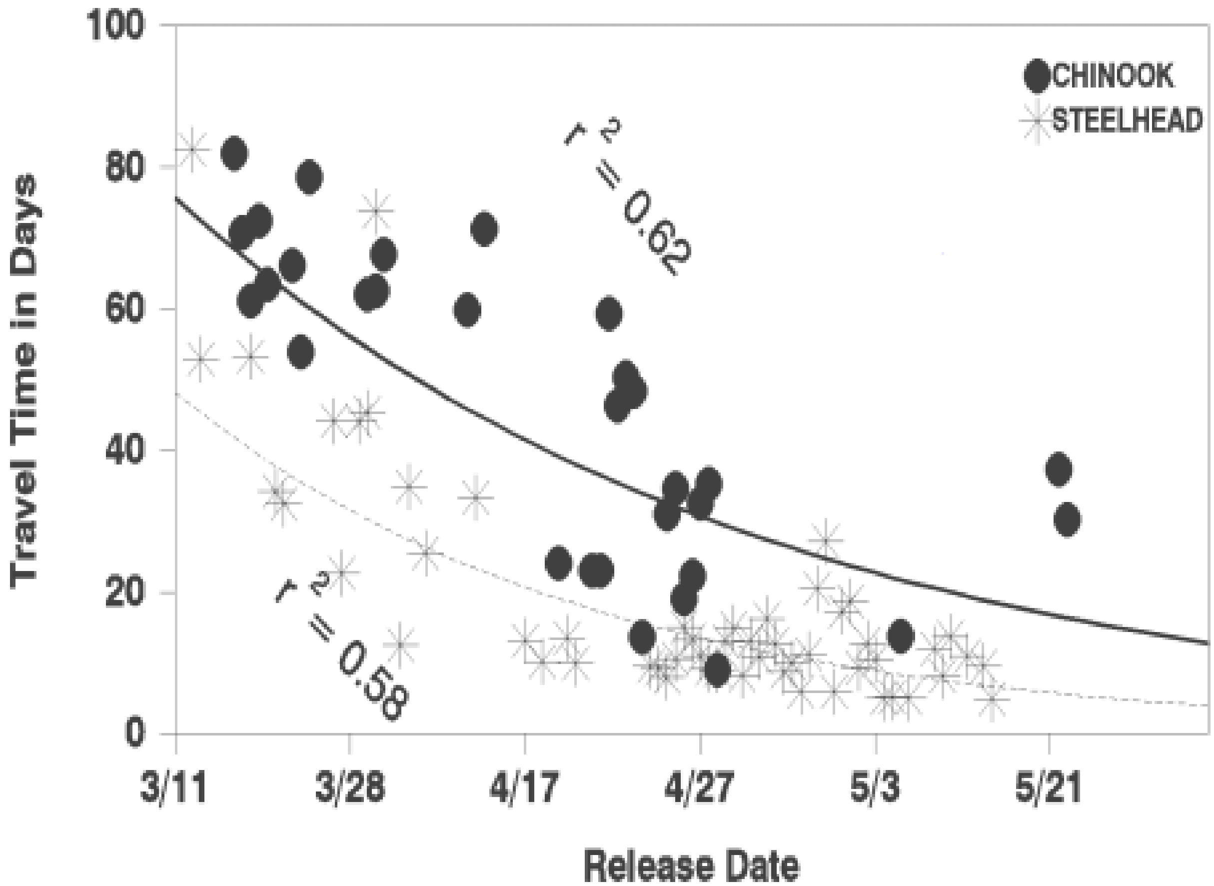

Figure 7. Spring 1993 chinook salmon and steelhead trout smolt travel time from the Crooked River trap to Lower Granite Dam.

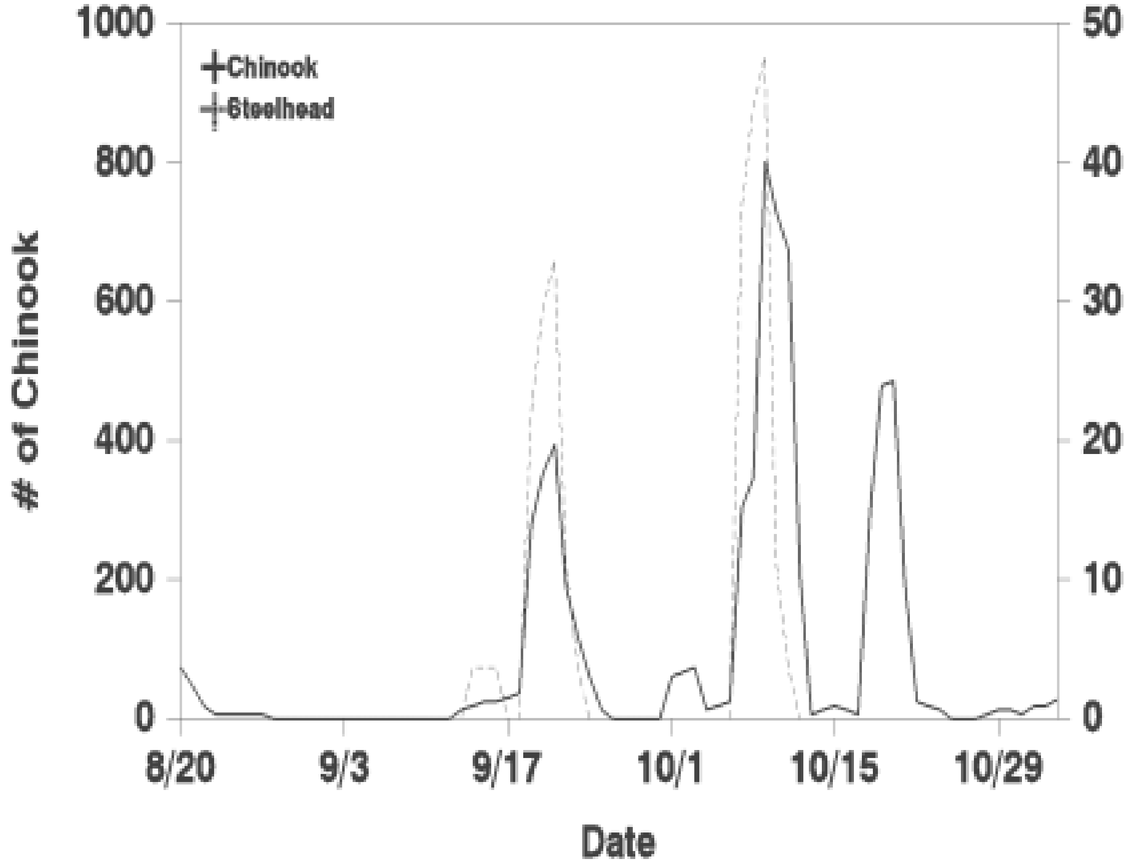

Figure 8. Fall 1993 Crooked River chinook salmon and steelhead trout emigration timing (3-day moving average).

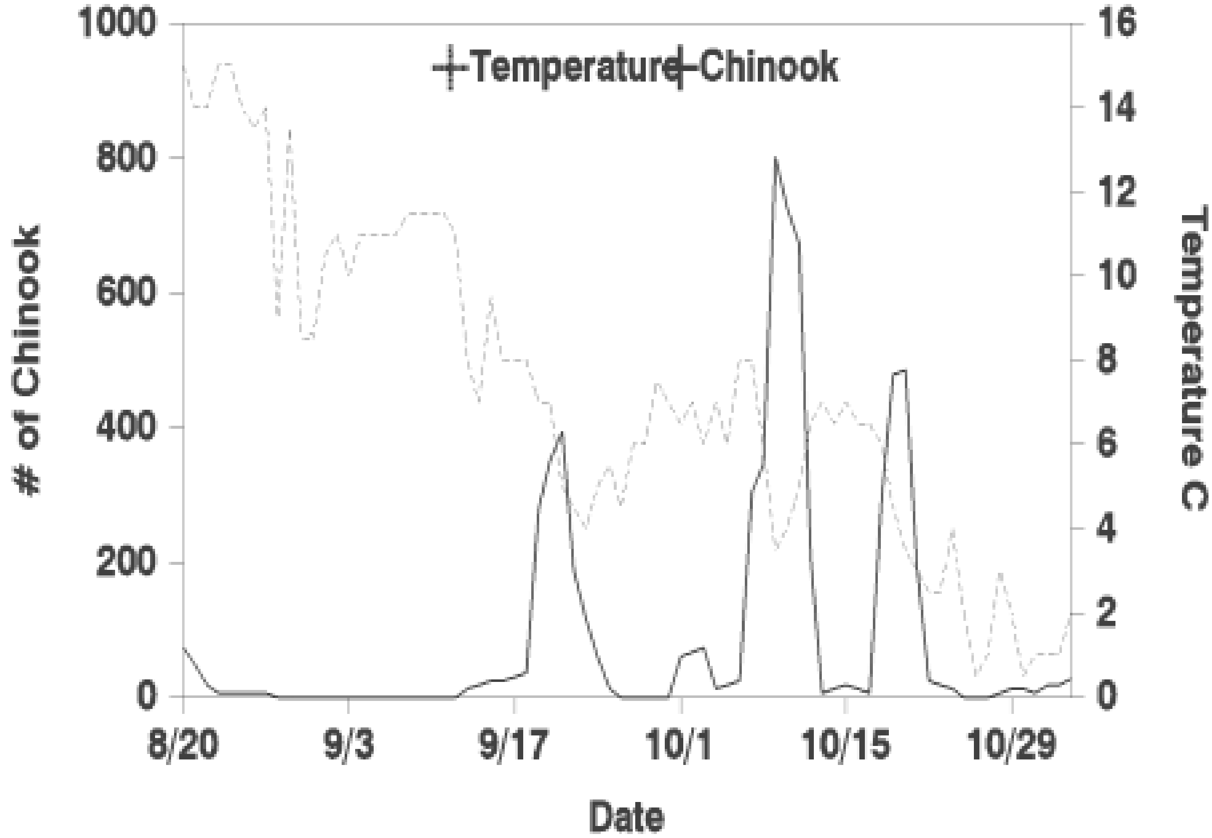

Figure 9. Fall 1993 Crooked River chinook salmon emigration timing (3-day moving average) and 09:00 water temperature.

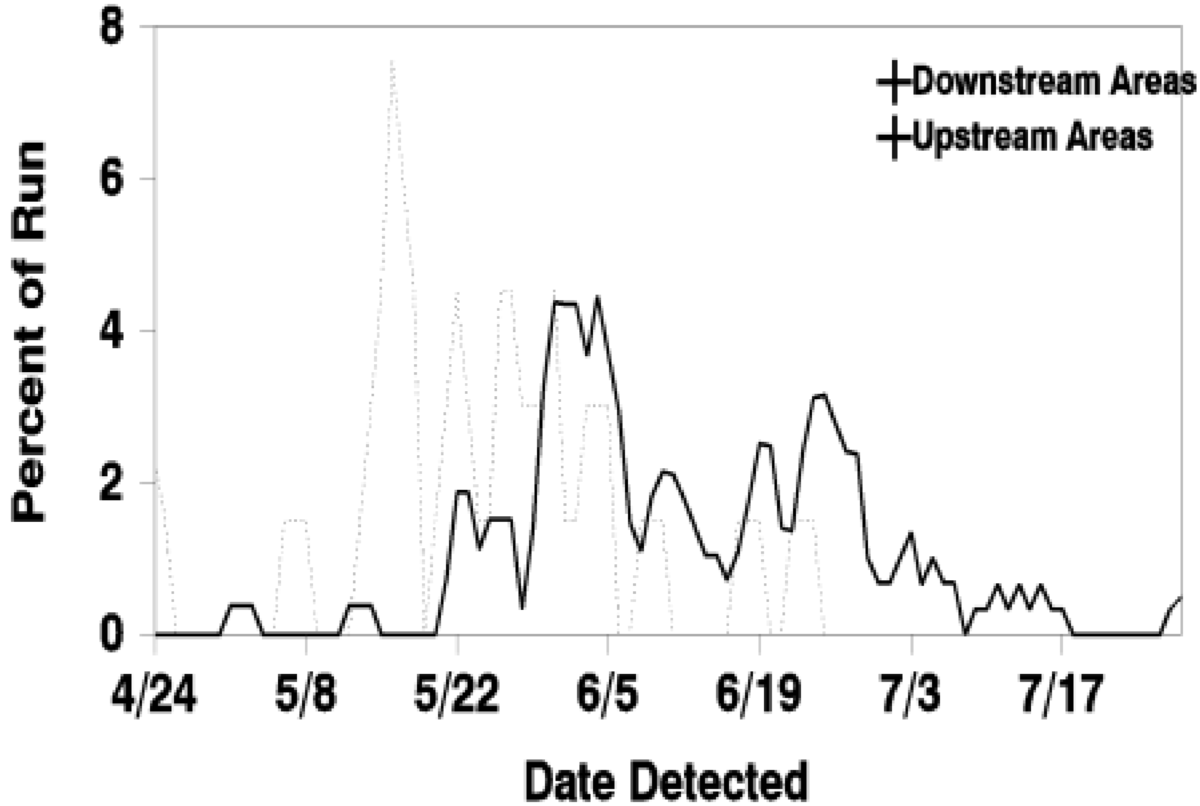

Figure 10. Arrival timing of chinook salmon smolts at Lower Granite Dam in 1993 from different areas of the upper Salmon River.

Table 1. Adult steelhead trout escapement, redd counts, and estimate of eggs deposited (in thousands) for Upper Salmon River, brood year 1987 to 1993. Total escapement, female escapement, and eggs/female data are from Sawtooth Hatchery brood year reports. Redd count data are from Idaho Department of Fish and Game redd count reports.

	Brood Year						
	1987	1988	1989	1990	1991	1992	1993
Total escapement	979	635	378	528	91	672	668
Female escapement	383	136	157	219	15	175	178
Helicopter redd counts; mainstream	—	—	—	56	15	29	36
Ground redd counts; tributaries	—	—	—	4	2		14
Eggs per female	4,854	5,069	5,637	4,734	4,019	4,581	4,460
Estimated eggs deposited	1,859.0	689.3	885.0	1,036.7	60.3	760.4	753.7

Table 2. 1993 Detections at the Lower Snake and Columbia River smolt collecting dams of August 1992 PIT-tagged parr from upper Salmon River.

	Chinook			Steelhead age-2+		
Stratum	Number Tagged	Number Detected	Percent Detected	Number Tagged	Number Detected	Percent Detected
FJC	216	13	6.0	39	3	7.7
ALC	550	81	14.7	2	0	0
FC	541	71	13.1	0	—	—
SR-3	556	10	1.8	1	0	0
SR-9	0	—	—	5	0	0
SR-HSC	432	13	3.0	3	1	33.0
TOTALS	**2,295**	**188**	**8.2**	**50**	**4**	**8.0**

Table 3. Smolt length and PIT tag detection at lower Snake and Columbia River smolt collecting facilities for upper Salmon River, spring 1993.

Length (mm)	Chinook Number Tagged	Chinook Number Detected	Chinook Percent Detected
<80	3	1	33.3
80-89	27	9	33.3
90-99	56	18	32.1
100-109	55	21	38.2
>109	17	7	41.2
Total	**158**	**56**	**35.4**

Length (mm)	Steelhead Number Tagged	Steelhead Number Detected	Steelhead Percent Detected
<90	21	0	0
90-129	39	2	5.1
>129	18	9	50.0
Total	**78**	**11**	**14.1**

Table 4. Density (number/100 m^2) of age-0 chinook in the upper Salmon River during July, 1987 to 1993.

Stratum	1987	1988	1989	1990	1991	1992	1993
Salmon R.							
3, 4	7.0	13.8	9.7	0.4	2.5	3.5	0.2
5, 6	0.3	4.1	3.6	0.1	0.1	0.4	<0.1
7	20.3	13.3	32.9	3.2	0.1	0.1	0
8	10.3	3.9	0.6	0	0	0.1	0
9	7.4	1.4	2.6	7.1	0	0	0
10	0.1	0	32.0	9.8	0	0	0
Salmon R. side channels							
3, 4	—	16.0	24.6	1.0	5.2	19.1	12.2
5, 6	—	17.9	0.6	1.2	0	0	0
7	—	16.1	85.7	4.7	0	1.4	0
8, 9, 10	—	6.8	1.7	0	0	0.4	0
Pole C.							
1	25.7	2.0	0.9	0	0	0	0
2	2.9	4.3	11.2	0.3	0.1	0	0
3	0	0.1	55.8	12.6	5.0	0	0.3
4	0	0	0.3	0	0	0	—
5	—	—	0	0	0	0	—
Alturas Lake C.							
1[a]	18.3	8.6	20.3	1.9	0.3	<0.1	0
2[a]	0.6	0.9	2.5	0.4	0	0.9	1.3
3[a]	0.1	0	7.7	0.1	0	6.4	1.0
4[a]						0.2	0
5[a]						0	0
Smiley C.							
1A[b]	35.2	6.9	14.1	0.3	0	0	0.2
1B[b]	1.1	13.5	23.4	0	0.3	0	1.6
2[b]						0	0
Beaver C.							
1	—	2.1	0.4	0	0	0	0
2	—	0.4	20.8	0.1	0	0	0
Frenchman C.							
1	0	0.6	4.0	0.4	0.3	0	1.0
2	0	41.4	109.5	10.2	87.9	79.4	4.7
Huckleberry C.							
1	—	—	—	—	0.2	2.3	0
2	—	—	—	—	0.2	—	—

Table 4. Continued.

Stratum	1987	1988	1989	1990	1991	1992	1993
Gold C.							
1	—	—	—	—	30.2	0	0
4th of July C.							
1	—	—	—	—	0	4.0	0
2	—	—	—	—	0	—	—
Pettit Lake C./Yellowbelly Lake C.[c]							
1	—	—	—	—	0	4.9	2.9
Champion C.							
1	—	—	—	—	0	0	2.0
2							0
Williams Creek							
1&2							5.4

[a] In 1992, Alturas Lake Creek stratum 1 was subdivided into three strata (1, 2, and 3). Stratum 2 was renamed stratum 4 and stratum 3 was renamed stratum 5.

[b] In 1993, Smiley Creek stratum 1 was renamed stratum 1A, stratum 2 was renamed stratum 1B, and stratum 3 was renamed stratum 2.

[c] In 1993, Pettit Lake Creek stratum 1 and Yellowbelly Lake Creek stratum 1 were combined into one stratum.

Table 5. Density (number/100m^2) of age-1+ steelhead parr in the upper Salmon River during July 1987 to 1993.

Stratum	1987	1988	1989	1990	1991	1992	1993
Salmon R.							
3, 4	0.1	0.2	<0.1	<0.1	0.1	0.1	0
5, 6	<0.1	0.1	0	0	<0.1	0	<0.1
7	0.7	0.4	0.2	0.3	0.5	0	0
8	0.4	0.4	0	0	0	0	0
9	8.5	2.8	2.6	4.5	0.1	0	3.6
10	7.3	3.5	8.4	4.5	0.1	0	3.5
Salmon R. Side channels							
3, 4	-	0.6	0.2	0.2	0.1	<0.1	<0.1
5, 6	-	0	0	0	0	0	0
7	-	0	0	0	0	0	0
8, 9, 10	-	0.3	0	0	0.2	0	0
Pole C.							
1	3.0	2.1	0.1	0.2	0.2	0.4	1.1
2	5.1	0	0.5	0.3	1.0	0.3	0.5
3	0	0	0.3	0.2	0.2	0	0
4	1.3	4.8	0.8	0	0	0	-
5	0	0	0	0	0	0	-
Alturas Lake C.							
1[a]	0.8	0.6	0.1	<0.1	<0.1	0	<0.1
2[a]						0	0.3
3[a]						0.1	0.4
4[a]	0.9	0.4	0	<0.1	0	0	0
5[a]	0	0.1	0.1	0.1	0	0	0
Smiley C.							
1A[b]	0.2	0	0.5	0.5	0.1	0	0
1B[b]	0	0.2	0.1	0	0	0	1.1
2[b]							0.1
Beaver C.							
1	-	0.5	0.1	0.6	0.3	0	0
2	-	0.2	0	2.0	0	0	0
Frenchman C.							
1	1.8	0	1.5	2.6	0	0	2.7
2	0	0.1	0	0	0	0	1.5
Huckleberry C.							
1	-	-	-	-	0	0	0
2	-	-	-	-	0.5	-	-

Table 5. (Continued.)

Stratum	1987	1988	1989	1990	1991	1992	1993
Gold C.							
1	-	-	-	-	0	0	0
4th of July C.							
1	-	-	-	-	0.7	0.1	0.7
2	-	-	-	-	0.4	-	-
Pettit Lake C./Yellowbelly C.[c]							
1	-	-	-	-	0.4/0.1	0/0	0.9
Champion C.							
1	-	-	-	-	-	-	1.1
2	-	-	-	-	-	0	0
Williams C.							
1&2	-	-	-	-	-	0	0.2

[a] In 1992, Alturas Lake Creek stratum 1 was subdivided into three strata (1, 2, and 3). Stratum 2 was renamed stratum 4 and stratum 3 was renamed stratum 5.

[b] In 1993, Smiley Creek stratum 1 was renamed stratum 1A, stratum 2 was renamed stratum 1B, and stratum 3 was renamed stratum 2.

[c] In 1993, Pettit Lake Creek stratum 1 and Yellowbelly Lake Creek stratum 1 were combined into one stratum.

Table 6. Density (number/100 m^2) of age-2+ steelhead parr in the upper Salmon River during July 1987 to 1993.

Stratum	1987	1988	1989	1990	1991	1992	1993
Salmon R.							
3, 4	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1
5, 6	<0.1	<0.1	0	0	0	0	0
7	0	0.1	0.2	0.1	0.3	0	0
8	0.2	0.1	0.7	0	0	0	0
9	2.1	0.8	0.9	0.4	0.1	0.6	0.8
10	2.4	2.9	4.4	0.5	0.2	0.2	0.7
Salmon R. side channels							
3, 4	—	0	0.2	0	0.1	0	0.2
5, 6	—	0	0	0	0	0	0
7	—	0	0.4	1.2	0.2	0	0
8, 9, 10	—	0	0	0	0	0.1	0
Pole C.							
1	1.2	0.6	0.1	0	0	0	0.4
2	1.6	0	0.3	0	0.1	0	<0.1
3	0.1	0	1.2	0.1	0	0	0
4	1.3	0.5	0.9	0.2	0	0.4	—
5	0.1	0.7	0	0	0	0	—
Alturas Lake C.							
1[a]	<0.1	<0.1	0.1	<0.1	0	0	<0.1
2[a]						0	0.2
3[a]						0	0.3
4[a]	0.5	0.3	0.1	0	0	0.1	0
5[a]	0	0.1	0.1	0.1	0	<0.1	0
Smiley C.							
1A[b]	0.6	0	0.6	0.3	0	0	0
1B[b]						0	0
2[b]						0	<0.1
Beaver C.							
1	—	0	0.1	0.4	0	0	0
2	—	<0.1	0	0.3	0	0	0
Frenchman C.							
1	2.2	0.6	2.3	1.0	0	0	0.9
2	0	0.1	0.1	0	0	0	0.2
Huckleberry C.							
1						0	0
2						—	—

Table 6. (Continued.)

Stratum	1987	1988	1989	1990	1991	1992	1993
Gold C.							
1	—	—	—	—	—	0	0
4th of July C.							
1	—	—	—	—	—	0.7	0.2
2	—	—	—	—	—	—	—
Pettit Lake C./Yellowbelly Lake C.[c]							
1	—	—	—	—	—	<0.1	0.7
Champion C.							
1	—	—	—	—	—	0	0.2
2						0	0
Williams Creek							
1&2							0

[a] In 1992, Alturas Lake Creek stratum 1 was subdivided into three strata (1, 2, and 3). Stratum 2 was renamed stratum 4 and stratum 3 was renamed stratum 5.

[b] In 1993, Smiley Creek stratum 1 was renamed stratum 1A, stratum 2 was renamed stratum 1B, and stratum 3 was renamed stratum 2.

[c] In 1993, Pettit Lake Creek stratum 1 and Yellowbelly Lake Creek stratum 1 were combined into one stratum.

Table 7. Adult chinook salmon escapement, redd counts, and estimate of eggs deposited (in thousands for Upper Salmon River, brood year 1986 to 1993. Total escapement, female escapement, and eggs/female data are from Sawtooth Hatchery brood year reports. Redd count data are from Idaho Department of Fish and Game redd count reports.

	Brood Year							
	1986	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**
Total escapement	876	506	552	470[c]	615	238	145	423
Female escapement	248	252	275	73[c]	167[d]	94	56	209
Helicopter redd count	105	124	76	52	60	46	29	61
Ground redd count	-	-	261	123	100	67	27	127
Eggs per female	5,156	5,399	5,653	5,456	4,501	5,192	4,503	4,834
Estimated eggs deposited[b]	1,278.7	1,360.5	1,554.5	671.1	450.1	347.9	193.7[e]	613.9

[a] Number is average eggs/female observed at Sawtooth Fish Hatchery.
[b] Estimates of average egg retention are incorporated in calculating egg deposition.
[c] Portions of the Sawtooth Fish Hatchery weir were pulled due to high water and uncounted fish probably passed the weir.
[d] Chinook escapement above Sawtooth Hatchery was reduced by at least 65 adults due to a rotenone kill.
[e] Because we believe we conducted our redd counts too early in 1992, we used the 1987—1992 average prespawning mortality observed at Sawtooth Fish Hatchery (5%) to estimate that 44 females spawned in 1992.

Table 8. Estimated chinook salmon egg-to-parr survival rates (%) from the headwaters of the upper Salmon River adult outplants and natural spawners, brood years 1987 to 1992.

Adult Origin	Population Parameter	Brood Years 1987	1988	1989	1990	1991	1992
Adult Outplants	Females outplanted	6	30	9	40	13	10
	Redds observed	5	30	9	13[a]	10	9
Natural Spawners	Redds observed	0	6	4	0	0	0
Combined Numbers	Egg deposition	26,995	203,508	72,800	58,513	51,917	39,627
	Parr production	8,625	35,938	5,054	18,214	19,838	1,509
	Egg-to-parr survival (%)	32.0	17.7	6.9	31.1	38.2	7.1[b]

[a] In 1990, we were unable to estimate total egg deposition in two of our outplant streams and data from these streams were not included in estimating egg-to-parr survival.

[b] Parr production estimates were biased downward due to uneven distribution of parr populations in outplant areas and we believe 7.1% to be more accurate.

Table 9. Estimated egg-to-parr survival rates for natural chinook salmon in the entire upper Salmon River, brood years 1984 to 1992.

	Brood Year							
	1984	1986	1987	1988	1989	1990	1991	1992
Estimated egg deposition in thousands[a]	1,095.1	1,287.7	1,360.5	1,724.2	688.8	450.1	347.9	193.7
Parr production in thousands	73.5	65.7	70.3	88.0	14.2	30.6	45.0	9.3
Egg-to-parr survival	6.7%	5.1%	5.2%	5.1%	2.1%	6.8%	12.9%	4.8%

[a] From Table 7.

Table 10. Headwaters upper Salmon River chinook salmon survival rate estimates, brood years 1987-1992.

	Brood Year					
	1987[b]	1988[c]	1989[d]	1990[e]	1991[f]	1992
Egg-to-parr[a]	32.0%	17.7%	6.9%	31.1%	38.2%	7.1%
Overwinter	15.5%	20.3%	18.9%	17.4%	18.2%	23.2%
Parr-to-smolt at Lower Granite pool	-	9.2%	6.4%	6.9%	5.7%	13.3%
Smolt migrating trap to Lower Granite pool	-	45.2%	33.7%	39.6%	31.1%	57.6%

[a] Data from Table 8.
[b] Data except for egg-to-parr survival from Kiefer and Forster 1990.
[c] Data except for egg-to-parr survival from Kiefer and Forster 1991.
[d] Data except for egg-to-parr survival from Kiefer and Forster 1992.
[e] Data except for egg-to-parr survival from Kiefer and Lockhart 1993.
[f] Data except for egg-to-parr survival from Kiefer and Lockhart 1995.

Table 11. Upper Salmon River age-2+ and older steelhead trout survival rate estimates, migratory years 1988-1993.

	Brood Year					
	1988[a]	1989[b]	1990[c]	1991[d]	1992[e]	1993
Overwinter	54.9%	48.0%	24.8%	14.5%	10.2%	16.0%
Parr-to-smolt at Lower Granite pool	23.3%	20.5%	7.8%	3.7%	3.0%	11.0%
Smolt migration; trap to Lower Granite pool	42.6%	42.4%	31.6%	25.7%	29.5%	68.6%

[a] Data from Kiefer and Forster 1990.
[b] Data from Kiefer and Forster 1991.
[c] Data from Kiefer and Forster 1992.
[d] Data from Kiefer and Lockhart 1993.
[e] Data from Kiefer and Lockhart 1995.

Table 12. 1993 Detections at the Lower Snake and Columbia River smolt collecting dams of August 1992 PIT tagged parr from Crooked River (CR).

	Chinook			Steelhead age-2+		
Stratum	Number tagged	Number detected	Percent detected	Number tagged	Number detected	Percent detected
CR-CAN	7	0	0	139	19	13.7
CR 1	1	0	0	74	12	16.2
CR 2	213	18	8.4	167	26	15.6
CR 3	1	0	0	84	19	22.6
RC	157	11	7.0	61	11	18.0
TOTALS	**379**	**29**	**7.7**	**525**	**87**	**16.6**

Table 13. Density (number/100m^2) of age-0 chinook salmon parr in Crooked River, August 1986 to 1993.

Stratum	Year 1986	1987	1988	1989	1990	1991[a]	1992	1993
Headwaters	—	—	<0.1	0.1	0	—	0	—
I	14.0	3.0	23.8	28.4	<0.1	—	0	1.1
II	1.1	16.5	19.7	19.7	<0.1	—	0.6	11.2
Canyon	—	—	8.0	10.3	1.0	—	<0.1	9.4
III	57.8	22.3	36.6	58.7	5.0	—	0.1	11.3
IV	71.8	15.4	42.2	59.0	4.7	—	0.1	3.1
Relief Creek	—	—	0.8	45.5	0	—	0.9	8.7
Ponds A[b]	62.9	3.2	65.4	206.1	0.6	—	0.3	53.4
Ponds B	—	—	—	268.0	8.1	—	0	31.7
Five Mile Creek	—	—	—	—	—	—	0	0.8

[a] Snorkel counts were conducted before the chinook age-0 parr probably emerged from the gravel, and none were observed.

[b] In 1986-1988 the data for connected ponds was combined and is reported here as Ponds A.

Table 14. Density (number/100 m^2) of age-1+ and age-2+ steelhead trout parr in Crooked River, 1987 to 1993.

Stratum	1987	1988	1989	1990	1991	1992	1993
				Age-1+ Steelhead Trout			
Headwaters	—	1.5	0.2	0.4	0.1	0.1	—
I	4.3	5.2	1.9	0.2	0.7	3.9	1.7
II	10.8	8.8	4.4	1.5	7.3	10.5	1.5
Canyon	—	11.4	4.1	1.0	4.7	8.4	0.7
III	6.1	10.3	6.5	2.5	2.8	13.3	1.2
IV	7.2	7.5	3.4	1.5	3.7	11.4	<0.1
Relief Creek	—	19.1	5.2	0.2	5.3	10.1	2.1
Ponds A[a]	42.4	17.8	7.2	1.2	0.6	3.4	0.7
Ponds B	—	—	10.1	0.1	1.7	8.3	0
Five Mile Creek	—	—	—	—	—	0.5	7.1
				Age-2+ Steelhead Trout			
Headwaters	—	0.2	0.3	0.1	0	<0.1	—
I	0.7	0.2	0.8	0.3	0.1	0.8	1.3
II	3.7	0.4	1.4	1.3	0.4	2.0	1.7
Canyon	—	1.2	2.1	1.2	0.4	2.2	1.8
III	2.8	0.5	1.8	1.4	0.1	2.4	1.4
IV	1.5	7.1	1.5	1.1	0.1	1.7	0.2
Relief Creek	—	0.6	1.8	0.1	0.5	2.4	0.7
Ponds A[a]	4.8	1.6	1.7	1.0	<0.1	1.2	0.8
Ponds B	—	—	2.2	0.3	0.2	0.8	0
Five Mile Creek	—	—	—	—	—	0	0.5

[a] In 1986-1988, the data for connected ponds was combined and is reported here as Ponds A.

Table 15. Estimated chinook salmon adult escapement, redd counts, and number of eggs deposited for Crooked River, 1985 to 1993.

	Chinook Salmon Brood Year								
	1985	1986	1987	1988	1989	1990	1991	1992	1993
Female escapement[a]	16	14	27	43	15	95	5	91	75
	10	9	17	27	3	-	-	-	-
Trend redd count									
	-	-	-	43	15	10[b]	4	54	54
Ground redd count	-	-	4,010	-	4,400	4,200	4,400	3,805	4,766
Eggs per female[c]									
Estimated number of eggs deposited (x1000)	67.54	59.09	108.27	181.50	66.00	399.00	17.60	205.47	247.85

[a] Female escapement was estimated for 1985-1987 based on 1/1 ratio of female escapement to ground counts observed in USR and 43/27 ratio of ground to trend redd counts observed in 1988. Female escapement in 1988 and 1989 was assumed to equal the ground redd count. Prespawning mortality is included.

[b] Redd counts were conducted before 157 adult chinook salmon (86 females) were outplanted into Crooked River from Dworshak National Fish Hatchery.

[c] Average number of eggs/female obtained from nearby Red River trapping facility minus average egg retention observed during ground redd counts.

Table 16. Estimated egg-to-parr survival rates for natural chinook salmon in Crooked River, brood years 1989 to 1992.

	Brood Year			
	1989	1990	1991	1992
Estimated egg deposition in thousands[a]	66.0	378.0	17.60	205.47
Estimated parr production in thousands	9,893	36,346	2,601	24,435
Egg-to-parr survival	15.0%	9.6%	14.8%	11.9%

[a] From Table 13.

Table 17. Crooked River chinook salmon survival rate estimates, brood years 1988-1992.

	Brood Year				
	1988[b]	1989[c]	1990[d]	1991[e]	1992
Egg-to-parr[a]	—	15.0%	9.6%	14.8%	11.9%
Overwinter	13.0%	12.0%	36.2%	34.7%	13.7%
Parr-to-smolt at Lower Granite pool	5.2%	5.7%	23.1%	15.8%	10.4%
Smolt migration; trap to Lower Granite pool	40.1%	47.4%	63.4%	34.1%	76.0%

[a] Data from Table 14.
[b] Data from egg-to-parr survival from Kiefer and Forster 1991.
[c] Data from egg-to-parr survival from Kiefer and Forster 1992.
[d] Data from egg-to-parr survival from Kiefer and Lockhart 1993.
[e] Data from egg-to-parr survival from Kiefer and Lockhart 1995.

Table 18. Crooked River age-2+ and older steelhead trout survival rate estimates, migratory years 1989-1993.

	Brood Year				
	1989[a]	1990[b]	1991[c]	1992[d]	1993
Overwinter	62.9%	25.2%	48.4%	48.2%	20.9%
Parr-to-smolt at Lower Granite pool	33.5%	14.1%	39.9%	32.8%	19.2%
Smolt migration; trap to Lower Granite pool	53.2%	55.8%	82.5%	68.1%	92.1%

[a] Data from Kiefer and Forster 1991.
[b] Data from Kiefer and Forster 1992.
[c] Data from Kiefer and Lockhart 1993.
[d] Data from Kiefer and Lockhart 1995.

Table 19. Comparison of detections rates at lower Snake and Columbia rivers' smolt collection facilities of parr captured by seine and electrofisher. Upper Salmon River = USR; Crooked River = CR.

Species	Tag Year and Site	Capture Method	Number Tagged	Number Detected	Percent Detected	Expected Number Detected	χ^2	Probability
Chinook	89USR	Seine	1,385	71	5.1	79	0.810	
	89USR	Shock	2,118	130	6.1	122	0.526	0.25>P>0.10
	90USR	Seine	814	43	5.3	41	0.098	
	90USR	Shock	261	11	4.2	13	0.308	0.75>P>0.50
	91USR	Seine	1,886	62	3.3	64	0.063	
	91USR	Shock	109	6	5.5	4	1.000	0.50>P>0.25
	92USR	Seine	1,873	152	8.1	157	0.159	
	92USR	Shock	422	41	9.7	35	0.457	0.50>P>0.25
	89CR	Seine	1,731	59	3.4	54	0.463	
	89CR	Shock	2,117	62	2.9	67	0.373	0.50>P>0.25
	90CR	Seine	592	78	13.2	75	0.120	
	90CR	Shock	155	17	11.0	20	0.450	0.50>P>0.25
Steelhead	91USR	Seine	44	3	6.8	2	0.500	
	91USR	Shock	223	7	3.1	8	0.125	0.50>P>0.25
	89CR	Seine	27	7	25.9	3	5.333	
	89CR	Shock	315	29	9.2	33	0.485	0.025>P>0.01
	90CR	Seine	48	18	37.5	18	0.000	
	90CR	Shock	204	75	36.8	75	0.000	- - - - - -
	91CR	Seine	348	177	50.9	176	0.006	
	91CR	Shock	61	30	49.2	31	0.032	0.90>P>0.75
	92CR	Seine	273	47	17.2	46	0.022	
	92CR	Shock	236	38	16.1	39	0.026	0.90>P>0.75

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Appendix A. July 1993 upper Salmon River parr abundance estimates and confidence intervals (α = 0.10).

Stream/Strata	Area (m^2)	Age- Chinook	Age-1+ Steelhead	Age-+ Steelhead
Salmon River				
SR-3/4	484,235	984 ± 1,643	0	43 ± 82
SR-5/6	154,476	57 ± 81	0	0
SR-7	87,651	0	0	0
SR-8	54,488	0	0	0
SR-9/10	64,097	0	2,265 ± 2,655	493 ± 597
Stream Total	**844,947**	**1,041 ± 1,520**	**2,294 ± 2,237**	**536 ± 509**
Salmon River Side Channels				
SR-3/4	39,513	4,833 ± 8,629	22 ± 51	89 ± 204
SR-5/6	7,056	0	0	0
SR-7/8	21,219	0	0	0
Stream Total	**67,788**	**4,833 ± 7,389**	**22 ± 44**	**89 ± 175**
Gold Creek	2,054	0	0	0
Huckleberry Creek	2,313	0	0	0
4th of July Creek	18,673	0	138 ± 614	40 ± 244
Champion Creek	14,740	123 ± 94	66 ± 101	13 ± 17
Alturas Lake Creek				
ALC-1	38,536	0	26 ± 71	4 ± 11
ALC-2	28,667	360 ± 1,813	91 ± 156	55 ± 20
ALC-3	22,249	233 ± 255	82 ± 47	66 ± 92
ALC-4	108,051	0	0	0
ALC-5	69,505	0	0	0
ALC-Tribs[a]	31,751	911 ± 2,159	272 ± 506	219 ± 358
Stream Total	**298,759**	**1,504 ± 1,701**	**471 ± 378**	**344 ± 270**
Pole Creek				
PC-1	13,095	0	140 ± 45	54 ± 148
PC-2	21,850	0	118 ± 197	19 ± 54
PC-3	17,190	45 ± 276	0	0
Stream Total	**52,135**	**45 ± 103**	**258 ± 163**	**73 ± 127**
Smiley Creek	81,715	343 ± 346	287 ± 326	30 ± 60
Beaver Creek	48,600	0	0	0
Frenchman Creek				
FC-1	3,229	33 ± 198	88 ± 225	29 ± 75
FC-2	25,049	1,166 ± 1,967	386 ± 414	40 ± 83
Stream Total	**28,278**	**1,199 ± 1,968**	**474 ± 421**	**69 ± 87**
Williams Creek	4,583	245 ± 695	11 ± 30	0
Study Area Total	**1,464,585**	**9,334 ± 6,733**	**4,060 ± 2,190**	**1,195 ± 565**

[a] Yellowbelly Lake Creek and Petit Lake Creek combined.

Appendix B. July 1993 Crooked River (CR) abundance estimates and confidence intervals ($\alpha = 0.10$).

Stream/Strata	Area (m^2)	Age-0 Chinook	Age-1+ Steelhead	Age-2+ Steelhead
Crooked River				
CR-4	33,410	1,031 ± 1,854	9 ± 25	63 ± 141
CR-3	28,678	3,254 ± 5,251	345 ± 525	413 ± 511
CAN-1	61,922	5,793 ± 15,086	406 ± 235	1,142 ± 967
RC-1	5,559	999 ± 1,515	76 ± 126	38 ± 29
RC-2	5,955	0	247 ± 567	86 ± 56
CR-2	39,229	4,390 ± 3,546	585 ± 666	674 ± 548
CR-1	54,891[a]	590 ± 487	957 ± 411	720 ± 370
5MC	646	5 ± 22	46 ± 91	3 ± 14
PND-A	3,660	1,955 ± 1,733	26 ± 26	30 ± 40
PND-B	20,253	6,417 ± 17,924	0	0
Study Area Total	**253,557**	**24,435 ± 14,835**	**2,697 ± 734**	**3,169 ± 851**

[a] For 1993, Strata 1 and the Headwaters Strata up the West Fork were combined.

Prepared by:

Russell B. Kiefer
Senior Fishery Research Biologist

Jerald N. Lockhart
Senior Fishery Technician

Approved by:

IDAHO DEPARTMENT OF FISH AND GAME

Virgil K. Moore, Chief
Bureau of Fisheries

Steve Yundt
Fisheries Research Manager